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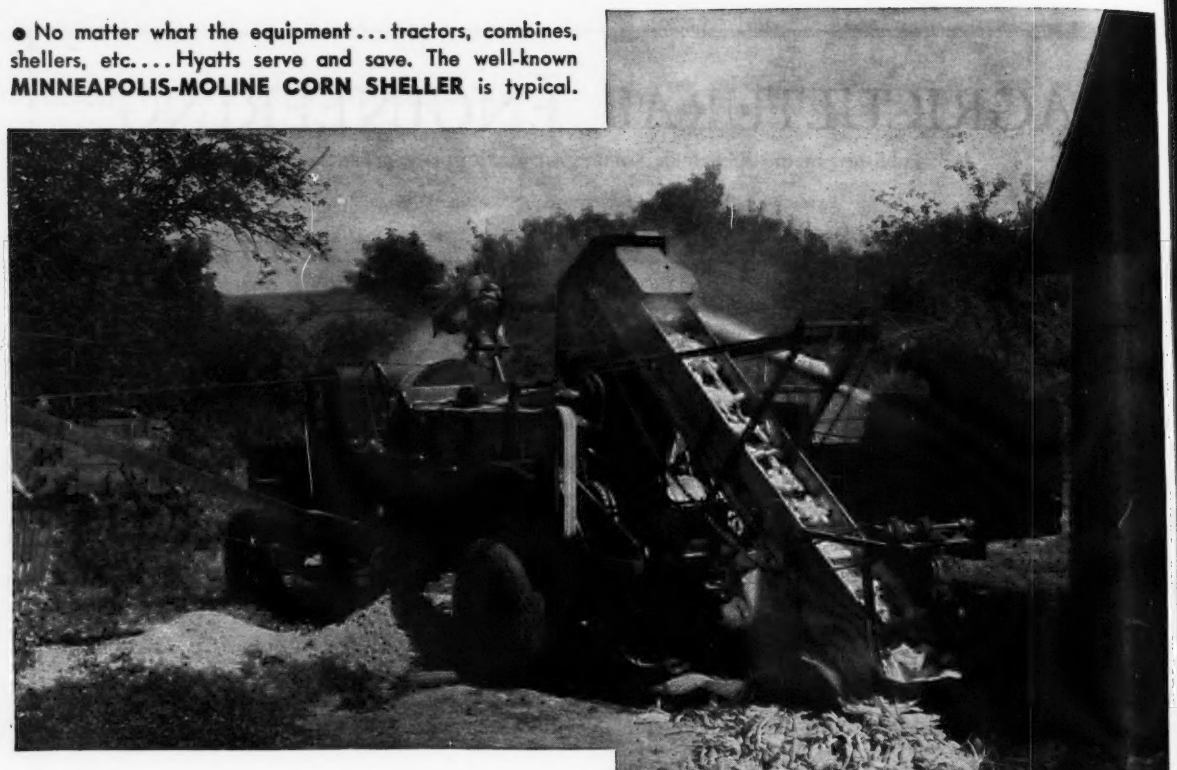

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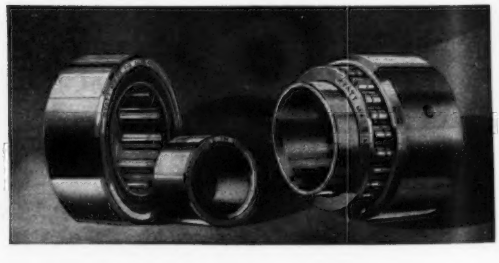


HYATT

ROLLER BEARINGS

AGRICULTURAL ENGINEERING

VOL 18, NO 12 EDITORIALS DECEMBER 1937

What Extension Men Want to Know

A COMPILATION of subject matter problems of agricultural engineering extension workers has been suggested by D. A. Milligan, chairman of the private industry group of the ASAE Committee on Extension.

Lists of agricultural engineering research problems have been made up from time to time under various auspices, with some participation by extension men. And extension men have had the benefit of contact with research men within their own organizations. In fact, there are numerous cases of individual agricultural engineers having both extension and research functions.

But this still leaves the field wide open for a compendium of important research problems from the viewpoint of extension agricultural engineers. Problems come up in their work on which they have difficulty in finding satisfactory information, or any information. Their own time for research, if any, is too limited to enable them to develop the required information themselves. The research departments of their own organizations are already occupied with other problems, and may have several valid reasons for not immediately undertaking to solve their extension men's problems.

Mr. Milligan has pointed out that extension agricultural engineers are field men, in daily contact with farmers and handlers of farm products, with first-hand, up-to-date knowledge of their problems. They have these problems put to them by a public which wants them answered, and answered soon. They are in a position to evaluate one problem against another as to relative importance. They have the technical background necessary to analyze a farmer's practical operating problem down to its separate technical elements, some factors of which are known and some unknown.

As Mr. Milligan has further pointed out, a preliminary list of proposed research problems contributed by extension men would probably, upon checking by both extension and research agricultural engineers, reveal some that are already solved, and some that are on their way to solution. It would reveal some problems for which solutions were requested by many extension men, along with others of more localized importance. It should be welcomed by research men as a challenge and as a guide to worthwhile research. For the extension man in Maine who has run into and stated a problem of broad significance, some research man in California may have the answer or important related information; he may already be working on the problem or in a position to start work on it immediately.

A professional and technical society is nothing if not a pool of basic information in its field and an agency for sponsoring the development, pooling, and distribution of needed new information. We believe Mr. Milligan has suggested a new and important contribution to this activity.

Low-Cost Housing

ASIDE FROM the auto-trailer variety of rolling real estate, there are two approaches to low-cost housing. The distinction is based on availability of natural building materials, and on economy of labor. One is the self-sufficient answer; the other the commercial attack.

A new Arkansas plan service handbook compiled by Deane G. Carter, head of the agricultural engineering department at the University of Arkansas, reminds us that low-cost housing is more than a commercial speculation in many of the less prosperous agricultural areas. It is a stark reality.

Where natural building materials are readily available, and where the farmer's cash income is limited by poor land, insufficient land, shortage of capital, poor markets, or any combination of these factors, the logical answer to his housing problem is the self-sufficient one. Common sense economics dictates that the man who is in a poor position to produce and exchange some special service or commodity, produce rather all he can for his own use. Materials being available, the lowest cost house for him is one he can build himself. Agricultural engineering help to him cannot be in terms of the latest or most ideal improvements. It can only be in terms of the one or two forward steps he can take now. Mr. Carter has been commendably practical in giving important place in his book to two-room farm house plans which will be within the reach of some farmers now living in one-room shacks or in two-room cabins which need rearrangement or replacement.

For the farmer in a favorable cash-crop position, or where natural building materials are not available; for the building supply interests which would enjoy his trade; and for the agricultural engineer who would help to improve his housing conditions, the hope of low-cost housing apparently lies in the direction of improved materials handling and fabrication methods.

There are completely prefabricated houses, partly prefabricated houses, prefabricated standard sections, mill work units, and various adaptable materials; but still not enough saving over comparable "tailor-made" houses is shown to start a revolution in building.

This suggests opportunity for more research in building construction as a materials handling and fabrication problem, toward utilizing efficient power equipment, and quantity production, both in plant preparation of building materials and units, and in their final assembly at building sites. One way toward commercial low-cost housing as a reality is for the builder to operate more and more with the controlled mechanical power and precision, quantity-production machinery which engineering research can give him.

Farm Power Economics

AN ASAE member interested in horse-drawn implements has suggested that the Society has been concentrating attention on tractors and tractor equipment to the neglect of animal power and the engineering of animal-drawn equipment. He suggests a study leading to the development of principles which individual farmers might use as a guide in deciding how best to meet their individual field power and field implement requirements.

This points again toward farm operating efficiency studies, such as the one in progress in the U. S. Bureau of Agricultural Engineering. The farmer's real interest is not in theoretical maximum production efficiency. He is interested in how he can proceed toward more efficient production from where he is, with what he has or can get. Many considerations are involved—his existing investment or fixed capital; available liquid capital for additional investment; balance of investment; his cash crop position as determined by markets and soil or geographic limitations; his individual limitations, inclinations, and preferences; comparative maintenance and operating costs, including cost of work-animal and animal-feed production; layout of farm and farm buildings, labor cost and efficiency, and overall effectiveness of management; cost and benefits of changing from one form of power to the other, of adding more of either form to his primary horsepower, or of maintaining some of both forms of power; and other items we have probably overlooked.

In addition to farmers and horse-drawn implement makers, the tractor industry might welcome an impartial study of this farm field power problem, without fear of the resulting conclusions and recommendations. We believe these manufacturers have been bedevilled enough with having their tractors and equipment sold where they will be operated, or stand idle, under conditions sure to produce dissatisfaction, resulting in increased sales resistance among neighboring farmers who might use tractors profitably.

The ASAE provides the machinery through which engineers representing both the tractor and tractor equipment industry and the horse-drawn implement industry might thresh out this problem. It is up to those who see the need and opportunity, however, to take the initiative and start something.

Sequel to National Planning

AMERICAN Engineering Council's executive office has released as substantial food for engineering thought an opinion by Leonard J. Fletcher, a past-president of the ASAE, as to national planning and its possible consequences.

In Mr. Fletcher's words, "The next step after national planning is plan enforcement. Plan enforcement and free competition cannot exist together—it is one or the other.

"With a people accustomed to exercising independent thought and action in their business and personal affairs, free competition is a mysterious force that operates without a central guiding hand. It displaces the inefficient, it allows the introduction of new inventions to proceed at just the right pace, not too fast or too slow. It keeps all of the people just a little bit dissatisfied with the things they have so that they are looking for new and better goods and services, and, incidentally, the means with which to obtain them.

"If the privilege of free competition is curtailed through the activities of a central planning board, even though its members be prompted by the highest of ideals, one of the most valuable possessions of the people of this country will be destroyed."

Amplifying Mr. Fletcher's opinion, the AEC release points out a distinction between "planning as an 'operational' function of management" and "planning in the broad sense of determining the 'strategies of civilization' and the determination of national policies for present or future generations of citizens."

Analyzing the question down to street and barnyard language it looks to us about like this, "Should some supermanagement be set up to manage managements, and if so why, how, and by whom?" And that page is torn out of our book of answers.

Trouble

AGRICULTURAL engineers may find some consolation and perspective in a motto which Dr. Charles F. Kettering says he has in his laboratory, namely, "The price of progress is trouble."

From this viewpoint, freedom from trouble would be a danger sign. Measured in units of trouble, agricultural engineers may be making more progress than is apparent from their position close to their work and specific individual troubles.

It is not that progress is an incidental benefit arising from any or all trouble. Rather, trouble is a necessary evil incidental to progress. Engineers trying to do anything progressive run into enough trouble without looking for it.

Quantity of trouble is no index to progress; it is the character of trouble that counts. Agricultural engineering troubles have changed in a measure, in the past few years, from the problems of overcoming tradition and gaining recognition, toward increasing problems of developing personnel, techniques, materials, and equipment to meet the demands of an increasingly progress-conscious public. That is an indication of progress and cause for considerable satisfaction. There is much more pleasure in being pushed to meet demands for service, than in struggling to justify one's existence.

Correction

IN THE editorial entitled "Farm Structures Progress" which appeared in our November issue, we referred to a paper by K. J. T. Ekblaw as being published in that issue. Mr. Ekblaw's paper, referred to in that editorial, appears elsewhere in this issue.

Irrigation by Sprinkling

By J. E. Christiansen

SPRINKLING with portable systems began in the Sacramento River delta region of California in 1931, although a few scattered installations were made in southern California before that time. Sprinkling with stationary systems had been confined largely to citrus orchards and truck crops. With the introduction of the portable systems, sprinkling became a feasible method of irrigating large acreages of field crops, such as sugar beets, beans, peas, and onions.

The division of irrigation investigations and practice of the University of California began a study of sprinkling with portable systems in 1932[1]. This study has five principal objectives:

1 To determine the uniformity of distribution of water from rotating sprinklers and especially to determine the effect of wind, pressure, speed of rotation, and spacing of sprinklers upon the resulting distribution.

2 To determine the loss of water by evaporation.

3 To determine the hydraulic characteristics of sprinkler systems, and to prepare tables and graphs from which friction losses in sprinkler lines could be readily ascertained. Such graphs are necessary to determine the proper sizes and combinations of pipe and sprinkler nozzles.

4 To determine the cost of applying water by sprinkling.

5 To determine the general success of sprinkling as a method of irrigation.

Description of Portable Sprinkler Systems. A portable sprinkler system consists essentially of a line of special light-weight pipe with quick-acting couplings, on which rotating sprinklers are mounted, together with a pumping plant. The pipe is ordinarily made up in 20-ft lengths with an outlet on each length. Sprinklers are usually mounted on every other outlet, or 40 ft apart. The pipe is moved across the field by one or two men carrying one length at a time. Sometimes three men carry two lengths at once. A number of different makes of systems are now available, each with a different kind of coupling. Some of the couplings used are shown in Fig. 1. During the first year only 4-in pipe was available in most of these systems, but now some of them can be obtained in 2, 3, 4, 5, and 6-in sizes and in any desired lengths. Special quick-acting couplings are also being manufactured for use on ¾-in and 1-in standard pipe. In orchards it is desirable to use pipe the same length as the tree spacing; and some users prefer 30-ft pipe for field crops, with a sprinkler for each length. A few of the sprinklers used are shown in Fig. 2.

Most of the systems operate with a portable plant pumping from a field ditch along one side, or through the center of the field. A typical portable pumping plant is shown in Fig. 3. With the supply ditch through the center of the field, a double-line arrangement is possible. This is much more efficient and should be used whenever feasible, as it necessitates that only one line be shut down at a time for moving pipe. With the same throttle setting and with only one of the two lines in operation, the pressure is increased about 50 per cent, and the total discharge is approximately 60 per cent of the two lines.

In areas where the water supply is obtained from wells or where, because of the topography, open ditches through the field are not feasible, a stationary pump and a main-pressure line with valve outlets are used. For such lines it is customary to space the valves three times as far apart as the line is moved each time, so that three settings are made from each valve. Sometimes portable main lines are used. These require no valves because they are connected directly to the laterals, additional lengths of pipe being added as the laterals are moved away from the pumping plant.

Distribution of Water from Sprinklers. Tests on the distribution of water from sprinklers were made at Davis. A total of 170 sprinkler distribution tests have been made,

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers at Urbana, Illinois, June 22, 1937.

Author: Assistant irrigation engineer, University of California. Assoc. Mem. ASAE.

[1]Results of a previous study of stationary systems were published in 1926. H. A. Wadsworth, Irrigation by overhead sprinkling. Calif. Agricultural Extension Service Circular 4.

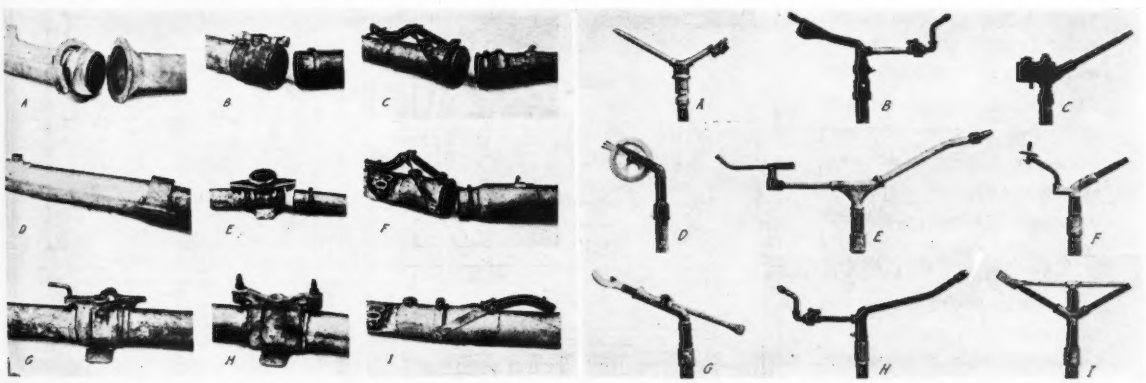


FIG. 1 (LEFT) SOME OF THE DIFFERENT TYPES OF PORTABLE SPRINKLER-PIPE COUPLINGS—(A) SHUR-RANE, BALL-AND-SOCKET TYPE, (B) MONTAGUE, (C) CALCO 3-IN, (D) RAIN STORM, (E) PIERCE, (F) CALCO 4-IN, (G) WILSON, (H) SHUR-RANE, (I)CALCO 4-IN COUPLED. FIG. 2 (RIGHT) SOME SPRINKLERS OF THE TYPE USED ON PORTABLE SYSTEMS TESTED FOR DISTRIBUTION OF WATER — (A) THOMPSON, (B) BUCKNER, (C) V AND B, (D) SPIN-A-RAIN, (E) NELSON'S LARK, (F) RAINWAY, (G) ORR, (H) BUCKNER, (I) RAIN BIRD. (SOME OF THESE ARE OLD MODELS NO LONGER MANUFACTURED)

most of them for a period of one hour. For the first 122 tests the water was caught in cans spaced 10 ft apart in both directions, except on the two diameters where they were 5 ft apart. For the last 48 tests additional cans were placed in the center of each square—one can for each 50 square feet. The water caught in the cans was measured in a graduated cylinder to the nearest cubic centimeter, or 1/200 in in depth. During the tests the wet-and-dry-bulb temperatures were determined for use in connection with evaporation studies. The wind velocity was obtained with a standard four-cup anemometer mounted in an exposed position about 10 ft above the ground. A return-pressure line from the base of the sprinkler riser was provided, and the pressure gage was mounted near the control valve so that a constant pressure could be maintained during the tests. Each test was plotted as shown in Fig. 4, which illustrates the distribution obtained with one sprinkler under very favorable conditions, that is, sufficient pressure, practically no wind, and a fairly slow and uniform rotation of the sprinkler.

Fig. 5 illustrates the effect of too low a pressure. For a pressure of 20 lb per sq in most of the water was distributed in a ring near the outside edge of the area wetted. The effect of wind is illustrated in Fig. 6. These figures show only the characteristics of a single sprinkler and give no information as to what happens when the sprinklers are spaced so that there is considerable overlap in each direction. Fig. 7 shows the resulting distribution corresponding to the pattern shown in Fig. 4, for the customary sprinkler spacing of 40 by 50 ft. The variation is from about 0.7 to slightly over 1.0 in. Fig. 8 shows what results from a low pressure of 20 lb per sq in. In this case the variation is from about 0.2 to more than 1.0 in, which could not be considered very satisfactory.

Uneven distribution is frequently due to a variation in the rate of rotation of the sprinkler. All sprinklers tested showed some variation in rate of rotation, although some showed much more than others. In one instance (Fig. 9) the average angular velocity was eight times as high when the main nozzle was discharging to the east as when it was discharging to the southwest. To secure data on rotation, an anemometer recorder was converted into a rotation recorder by gearing it so that the drum rotated at a speed of 1 in in 50 sec. A commutator arrangement attached to the sprinkler closed the electrical circuit every

FIG. 3 PORTABLE PUMPING PLANT OPERATING TWO ¼-MI LINES OF 4-IN AND 5-IN PIPE WITH 61 SPRINKLERS. CAPACITY ABOUT 1,100 GAL PER MIN

30 or 60 degrees, as desired; and thus the actual rate of rotation for a large number of revolutions was automatically recorded. The tests show that uneven rotation is not due to wind as is commonly believed.

Another factor that greatly affects the distribution of water from a sprinkler is its speed of rotation. To obtain maximum coverage, a sprinkler should rotate not faster than 1 rpm. Often they rotate as slowly as 1/5 rpm. The more slowly they rotate the farther they throw the water. Sometimes sprinklers are improperly adjusted and are allowed to rotate at speeds of 20 rpm or more. In one instance an actual count showed a sprinkler to be operating at a speed of 90 rpm. The effect of a high speed of rotation is shown in Fig. 10. At a speed of only 13.6 rpm, the area covered was reduced to about 55 per cent of that covered at a speed of 1 rpm, and the actual rate of application was almost doubled. Unless the spacing was proportionately reduced, the uniformity of application would be very poor.

Type of Sprinkler Pattern for Most Uniform Distribution. A detailed analysis of all the sprinkler tests, together with a number of geometrical patterns, showed that the most uniform distribution resulted from a conically-shaped pattern where the application was a maximum at the sprinkler and tapered off uniformly to the edges of the

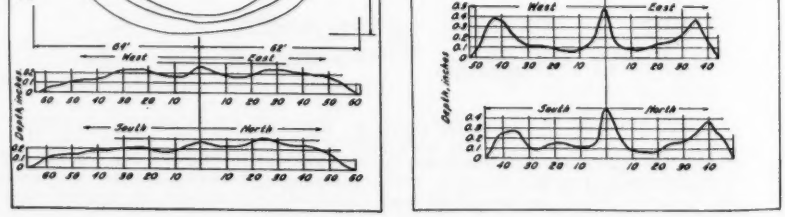


FIG. 4 (RIGHT) DISTRIBUTION OF WATER FROM SPRINKLER WITH 9/32-IN AND 3/16-IN NOZZLES, OPERATING AT 45-LB PRESSURE; SPRINKLER ROTATION, 0.7 RPM. REPRESENTATIVE OF SPRINKLERS OPERATING UNDER FAVORABLE CONDITIONS. FIG. 5 (EXTREME RIGHT) EFFECT OF LOW PRESSURE (20 LB PER SQ IN) ON DISTRIBUTION OF WATER FROM SPRINKLER WITH 5/16-IN AND 5/32-IN NOZZLES; ROTATION OF SPRINKLER, 0.6 RPM

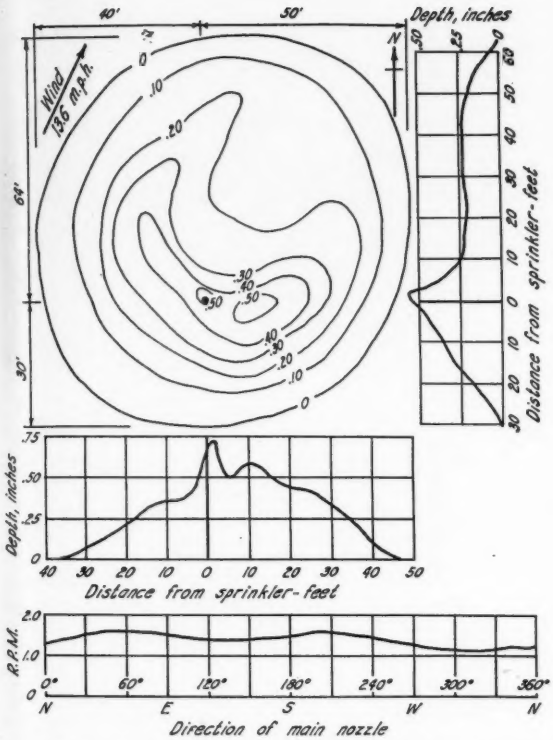


FIG. 6 EFFECT OF WIND ON DISTRIBUTION OF WATER FROM SPRINKLER WITH 5/16-IN MAIN NOZZLE. PRESSURE, 40 LB; WIND, 13.6 MPH; ROTATION, 1.3 RPM

area wetted. An example of such a pattern is shown in Fig. 11. Sprinklers with this type of pattern should be spaced fairly close together along the line, and not more than 60 per cent of the diameter covered in the other direction. A spacing along the line of about half the spacing between lines, or distance the line is moved, is

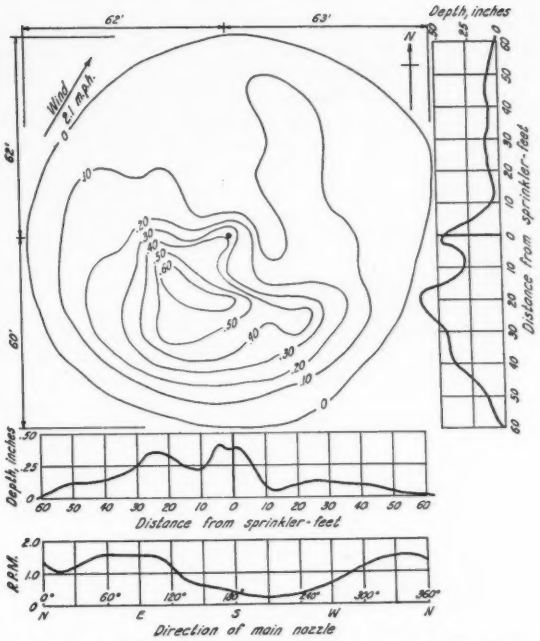


FIG. 9 DISTRIBUTION OF WATER FROM SPRINKLER WITH VARIABLE RATE OF ROTATION; PRESSURE, 40 LB PER SQ IN

quite satisfactory. The customary spacing of 40 ft between sprinklers will give good results when the sprinklers are performing properly. For low pressures and for sprinklers that rotate rapidly, 40 ft is too far.

Evaporation Losses. According to evaporation studies, the loss from the spray is very little, although the loss from the wet ground and vegetation may be appreciable. The distribution tests were planned so that a measure of evaporation loss could be secured at the same time. With the large number of cans spaced uniformly over the area, it was thought that the total amount caught in all the cans

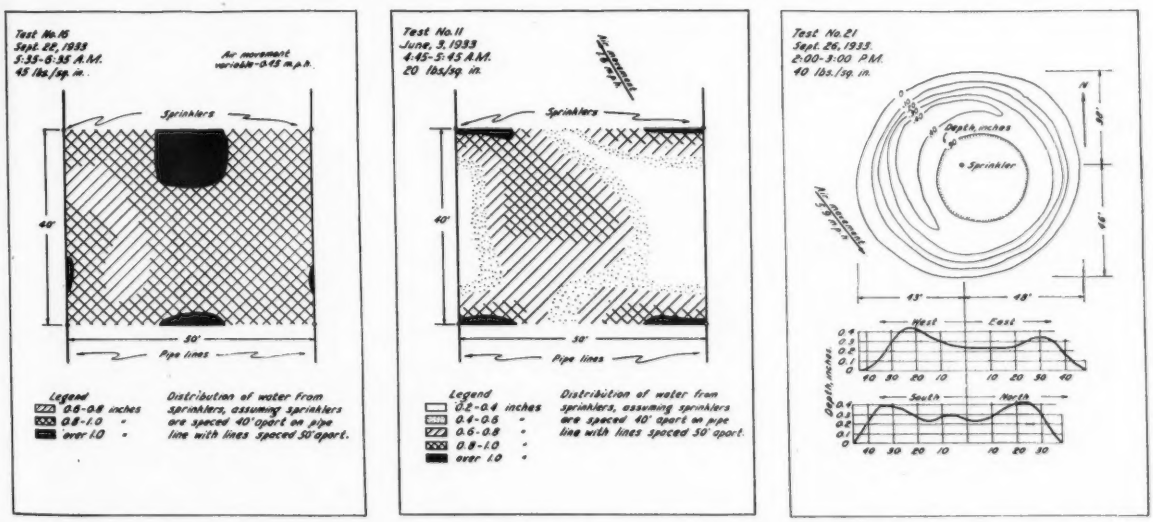


FIG. 7 (LEFT) RESULTING DISTRIBUTION OF WATER FROM SPRINKLERS HAVING PATTERN SHOWN IN FIG. 4, SPACED 40X50 FT APART. THIS IS A CUSTOMARY SPACING AND GIVES SOME IDEA AS TO THE UNIFORMITY OBTAINED UNDER FAVORABLE CONDITIONS. FIG. 8 (CENTER) RESULTING DISTRIBUTION FROM SPRINKLERS HAVING THE PATTERN SHOWN IN FIG. 5, SPACED 40 X 50 FT APART. THIS SHOWS WHAT OCCURS WHEN SPRINKLERS ARE OPERATED UNDER INADEQUATE PRESSURES. FIG. 10 (RIGHT) EFFECT OF HIGH RATE OF ROTATION ON COVERAGE AND DISTRIBUTION OF WATER FROM SPRINKLER WITH 9/32-IN AND 5/32-IN NOZZLES. ROTATION, 13.6 RPM. DIAMETER COVERED IS 115 TO 120 FT UNDER SIMILAR CONDITIONS BUT WITH RATE OF ROTATION LESS THAN 1 RPM

would give a fair measure of the total amount falling on the area. Judging from the results obtained, this method did not prove satisfactory for determining the evaporation loss from the spray because of the excessive loss of water from the cans during the test and the period of measurement. To reduce the loss from the cans, funnels were soldered into the tops of the cans. Although this precaution proved quite effective in reducing the loss from the cans, it did not significantly reduce the measured losses because some of the water evaporated directly from the surface of the funnels.

The evaporation of water from the spray can be determined approximately from thermodynamic principles. The heat required to evaporate the water is provided from three sources: the water, the surrounding air, and radiation—principally insolation. Studies show that the amount of heat contributed to a drop of water by radiation during its flight is small and can be neglected. The relative amounts of heat contributed by the water and air depend upon the air and water temperatures and the humidity.

The approximate relation derived by the author is

$$E = \frac{100\ C\ \Delta t}{r} \left[\frac{P_w - P_a}{P_w - P_a - 0.00037\ B\ (t_a - t_w)} \right]$$

where E is the loss of water from the spray expressed as a percentage of the amount discharged

C is the specific heat of water, calories per gram per degree F

r is the heat of vaporization, calories per gram

Δt is the drop in temperature of the water from the time it leaves the nozzle until it reaches the ground

t_w is the mean water temperature, degrees F

t_a is the air temperature, degrees F

P_w is the vapor pressure of water at temperature t_w, inches of mercury

P_a is the pressure of the water vapor in the air, inches of mercury

B is the barometric pressure, inches of mercury.

Evaluating the constants, letting

$C = 0.555$, $r = 585$, and $B = 30$,

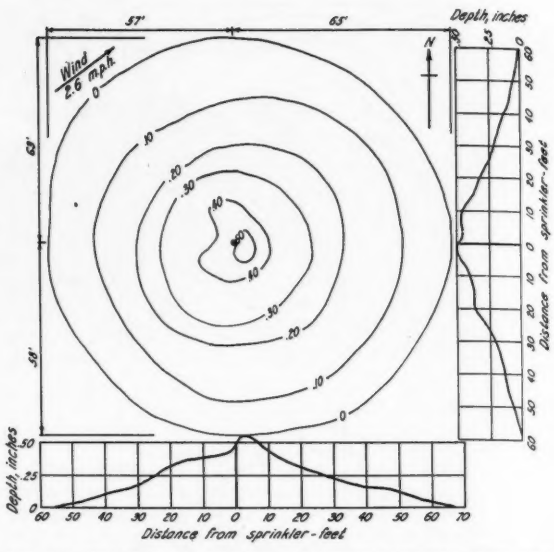


FIG. 11 EXAMPLE OF CONICAL SPRINKLER PATTERN. THIS TYPE OF PATTERN RESULTS IN A VERY UNIFORM DISTRIBUTION WHEN SPRINKLERS ARE SPACED CLOSE TOGETHER ALONG THE LINE, AND LINES ARE SPACED APART ABOUT ONE-HALF THE DIAMETER COVERED

the expression becomes

$$E = 0.095\ \Delta t \left[\frac{P_w - P_a}{P_w - P_a - 0.011\ (t_a - t_w)} \right]$$

A number of determinations of the temperature drop in the water between the sprinkler and the ground were made on field installations and at Davis. The evaporation losses for these tests, calculated from the above formula, did not exceed one per cent. The drop in temperature, and therefore the evaporation loss, depends largely upon the size of drops, which in turn depends upon pressure, wind, and type of sprinkler. It appears, however, that the loss from the spray is very little and that the principal loss by evaporation is from the wet surfaces of soil and plants during and following the application of water. This loss frequently amounts to a large part of the total applied, especially when frequent light applications are made.

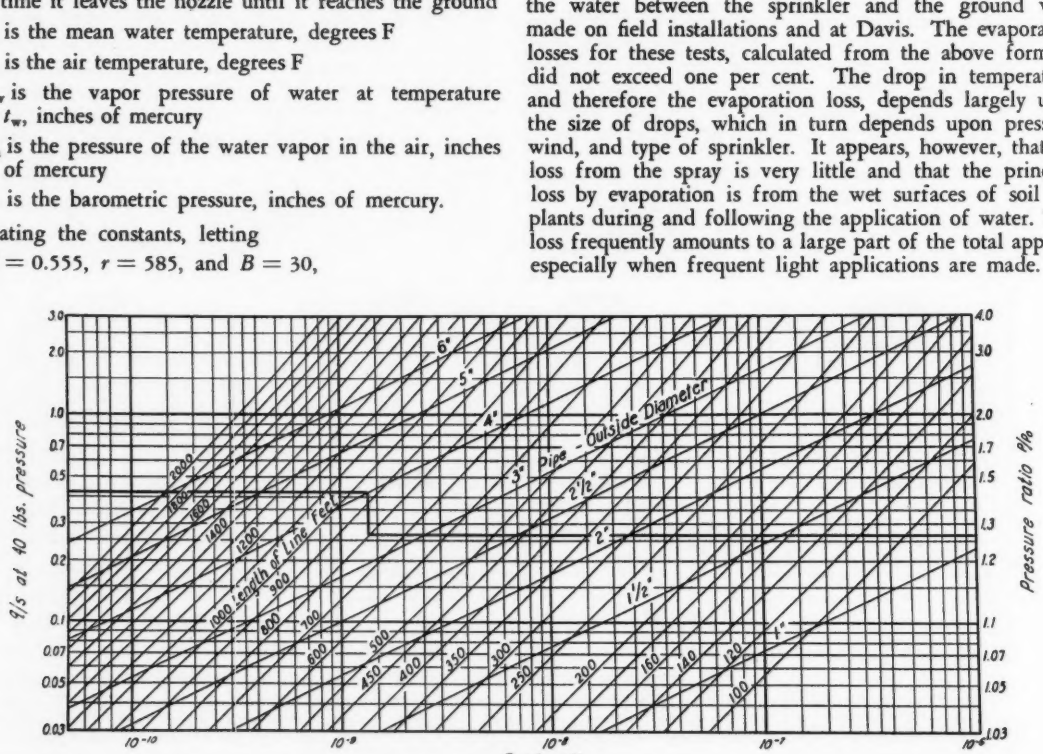


FIG. 12 LOGARITHMIC DIAGRAM FOR DETERMINING PRESSURE LOSSES IN 16-GAGE PORTABLE SPRINKLER LINES

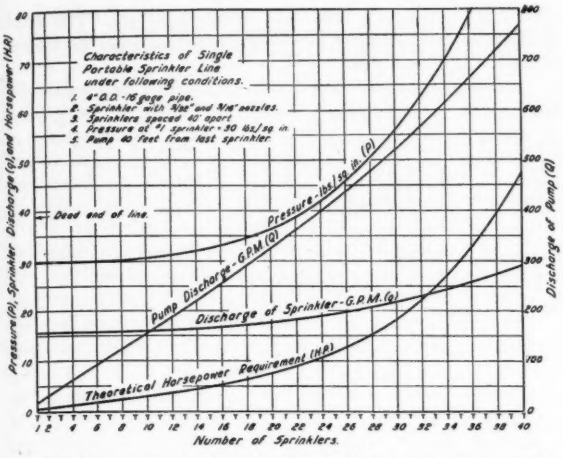

Characteristics of Single Portable Sprinkler Line under following conditions.
1. 4" O.D. -16 gage pipe.
2. Sprinkler with 1/32" and 3/16" nozzles.
3. Sprinklers spaced 40' apart.
4. Pressure at 1 sprinkler = 30 lbs/sq in.
5. Pump 40 feet from last sprinkler.
Dead end of line.
Pressure - lbs/sq in (p)
Pump Discharge - G.P.M. (Q)
Discharge of Sprinkler - G.P.M. (q)
Theoretical Horsepower Requirement (HP)
Pressure (p), Sprinkler Discharge (q), and Horsepower (HP)
Discharge of Pump (Q)
Number of Sprinklers.

FIG. 13 HYDRAULIC CHARACTERISTICS OF PORTABLE SPRINKLER LINE

Friction Losses in Sprinkler Pipe. A series of field tests were made to determine the friction factors or coefficients for the special pipe and couplings used for sprinkler systems. These tests presented considerable difficulty, as pipe-line velocities were sometimes as high as 15 ft per sec, with pressures of 60 lb or more per square inch. A transverse Pitot tube for measuring the flow did not prove entirely satisfactory. The method finally adopted consisted of calibrating the sprinklers to determine the relation between pressure and discharge for all nozzle combinations, and then determining the pressure along the line by means of a pressure gage and a special fitting that was slipped over the sprinkler nozzle. It was necessary, of course, to correct for the increase in pressure caused by shutting off the flow of the nozzle being tested. In this manner a reading was taken on each sprinkler on a line, from which the sprinkler discharge and the total discharge were determined from the calibration. The friction factor for the pipe was obtained by first plotting the pressure losses between adjacent sprinklers against the flow in that section of pipe, and drawing in a curve that best represented the data.

These tests indicated that the pressure losses were proportional to the square of the flow or velocity in the pipe, instead of some lower power as given by Scobey's or Williams and Hazen's formulas. This was found to be due to the partial recovery of velocity head at each sprinkler where the mean velocity in the pipe is reduced. For this reason the Weisbach formula

$$H_f = \frac{f L V^2}{2 g D},$$

was adopted, and the average value of f was found to be about 0.018, there being no appreciable difference between different makes of pipe tested.

For convenience, the Weisbach formula can be written

$$P_f = \frac{0.0134 f L Q^2}{d^5},$$

where P_f is the friction loss in pounds per square inch, L is the length of the line in feet, Q is the flow in gallons per minute, and d is the inside diameter of the pipe in inches.

One of the most difficult problems in the design of sprinkler systems is to calculate pressure losses along a line with a large number of sprinklers. Ordinarily this is done by calculating the loss between each two adjacent sprinklers; but for long lines, with twenty or more sprinklers, this becomes a very tedious task. Furthermore, in calculations of this kind one must begin at the farther end of the line and work back toward the source, beginning with an assumed pressure. A precise algebraic formula for the loss of pressure in a long line of pipe with a number of outlets is very involved and has little practical value. One can derive approximate expressions, however, from which the pressure loss can be determined quite accurately for limited conditions. If one assumes the sprinklers are spaced s feet apart, and each discharges the same amount of water, q, the total loss for a line with N sprinklers and N spaces would be

$$P_t = \frac{0.0134 f s q^2 \Sigma N^2}{d^5}.$$

Because of the friction loss along the line, however, each sprinkler does not discharge the same amount of water, assuming that the same nozzle sizes are used throughout. If the total pressure loss is relatively small as compared with the pressure on the line, and if the calculations are based on the average discharge of the sprinklers, the result will check that determined by detailed calculations very closely. The value of the ΣN^2 can be determined from the expression

$$\Sigma N^2 = \frac{N^3}{3} + \frac{N^2}{2} + \frac{N}{6}.$$

It has been found possible, however, to plot a logarithmic chart, Fig. 12, from which friction losses can be quickly determined for 16-gage pipe in sizes ranging from 1 in to 6 in outside diameter. Since our tests on friction losses covered only 4-in and 5-in pipe, this graph is based on friction factors, as given by Pigott[2] for new smooth steel pipe and for Reynolds numbers corresponding to velocities of 6.5 ft per sec. These values are based on an exhaustive study of data on flow of fluids in pipe. The values for f used for the different pipe sizes were as follows: 1-in, 0.028; 1½-in, 0.025; 2-in, 0.023; 2½-in, 0.022; 3-in, 0.021; 4-in, 0.020; 5-in, 0.019; 6-in, 0.018. These values, being slightly higher than those obtained from the tests on 4-in pipe, are therefore safer to use for design purposes.

To incorporate all the factors on one graph it was necessary to plot values of q/s at 40-lb pressure, representing the discharge per foot of line at a pressure of 40 lb per sq in, against a parameter K, and then to plot K against the length of line, L, to obtain the pressure ratio P/P_0, where P is the pressure at any distance (L) from the far end of the line, at which the pressure is P_0. For example, to find the friction loss in 800 ft of 4-in pipe, with sprinklers discharging 17.0 gal per min at 40-lb pressure, spaced 40 ft apart, one would enter the left side of the diagram with

$$q_{40}/s = 17/40 = 0.425,$$

follow to the right to the intersection with the 4-in pipe line, then vertically downward to the intersection with the 800-ft line, then to the right margin to obtain $P/P_0 = 1.27$. If the end pressure is $P_0 = 30$ lb, the pressure 800 ft from the end would be $1.27\ P_0 = 38.2$ lb, and the pressure loss $= 8.2$ lb. This diagram has been found very convenient for determining the proper pipe size for a given set of conditions or for determining the permissible length of

[2]Pigott, R. J. S. The flow of fluids in closed conduits. Mechanical Engineering 55(8):497-501, 515. August, 1933.

pipe of each size in a combination line having two or more pipe sizes.

Some other relationships help simplify the solution of sprinkler-pipe problems. The discharge of any sprinkler on a line, assuming that all sprinklers have the same nozzle sizes, is given by the expression

$$q = q_o \sqrt{P/P_o} = q_o\,[1 + 0.5\,(P/P_o - 1)] \quad \text{(approximately)}$$

where P and q are the pressure and discharge of the same sprinkler. The average discharge of all of the sprinklers is approximately

$$q_a = q_o\,[1 + 0.12\,(P/P_o - 1)]$$

where P is the pressure at the sprinkler nearest the source of supply. The total discharge of the line is $Q = N\,q_a$, and the horse power requirement is $QP/1715E$, where E is the efficiency of the pump and drive, and P is the pressure corresponding to the total pumping head, including suction lift.

In planning small systems it is good practice to proportion the pipe sizes and nozzle sizes so that the overall pressure ratio does not exceed 1.2. On large systems it is not always advisable to limit the ratio to this amount, since pipe larger than 4-in outside diameter is heavy and difficult to carry. Many systems in use have pressure ratios in excess of 2.0. For some tested, the ratio was approximately 3.0. Needless to say, such systems are very inefficient, and the pressure at the end of the line is generally altogether too low for satisfactory sprinkler performance.

Fig. 13 shows the hydraulic characteristics of a portable sprinkler line. The actual horsepower requirement can be determined by dividing the theoretical requirement by the efficiency of the pump and drive. Efficiencies from 50 to 70 per cent are assumed for this purpose. This graph emphasizes the advantages to be gained from using two short lines, supplied from a source through the center of the field, instead of a single line of twice that length, supplied from a source along one side of the field.

Studies have been made to determine the cost of operating sprinkler systems. Field tests were made on twenty-two systems operating with double lines and on seventeen systems with single lines. From these data, together with information obtained from the owners regarding fuel and labor costs, the approximate costs per acre-inch of water applied were calculated. The average operating cost for the twenty-two systems with double lines was 51 cents per acre-inch for labor and 20 cents for power (fuel, lubricating oil, and miscellaneous items), or a total of 71 cents per acre-inch, exclusive of depreciation and maintenance. The seventeen systems with single lines averaged 72 cents for labor and 26 cents for power, or 98 cents per acre-inch. Two large systems using 5-in pumps and diesel tractors for power showed costs of 36 and 39 cents for labor and 7 and 8 cents for power, respectively, or total operating costs of 43 and 47 cents per acre-inch. The average acreage covered per day was 12.5 for the systems with double lines and 8.3 for the systems with single lines. The average daily output was 31.7 acre-inches for the double-line systems and 16.0 acre-inches for the single-line systems, making the average applications 2.5 and 1.9 in, respectively. Since two men were employed on most systems the difference in output accounts largely for the difference in costs. All these systems used portable plants pumping from field ditches. Overhead and depreciation costs vary greatly with different conditions and are difficult to determine with any degree of accuracy. Portable sprinkler pipe has not been in use sufficiently long to determine its economic life. For most systems, however, depreciation costs are much less than operating costs. The total investment in equipment is sometimes less than the operation cost for one year.

A portable system that can be moved by one man with the aid of a tractor was devised and used by one grower in a lemon orchard during 1936. This system proved very satisfactory. It could be moved from one position to another in less than an hour and required practically no attention between moves. The general arrangement is shown in Fig. 14. Plans have been worked out for a similar arrangement for field crops, although for such use many difficulties must be overcome. It is believed that the extent of the use of portable sprinkler systems in the future will depend largely upon satisfactory methods being devised for reducing the labor costs. The cost of operation is undoubtedly the limiting factor in sprinkling.

During 1936 a survey was made to determine the present use of portable systems. Returns were received from 160 growers who were using portable sprinkler systems on a total of more than 27,000 acres. Judging from these returns, approximately 50,000 acres are now irrigated in California by this method. Sugar beets led all crops in acreage. In reply to the question "Do you believe you have been able to increase your yields by sprinkling?" 145 of the users replying answered as follows: Yes, 116; uncertain, 11; no, 18.

Our studies indicate that portable sprinkler systems have generally proved satisfactory in areas with a high water table and in some places near the coast where the seasonal water requirement is low. They are satisfactory for irrigating spring crops, such as peas, that require only one or two light applications in addition to the normal winter rainfall. They are especially well adapted to land of irregular topography that is difficult to irrigate by surface methods, and for shallow or coarse-textured soils of low water-yielding capacity that require light applications at frequent intervals. Sprinkling is a method that is generally satisfactory for special conditions where surface irrigation is not feasible or practical. It is limited principally by the cost, which for most conditions is higher than for surface methods of irrigation.

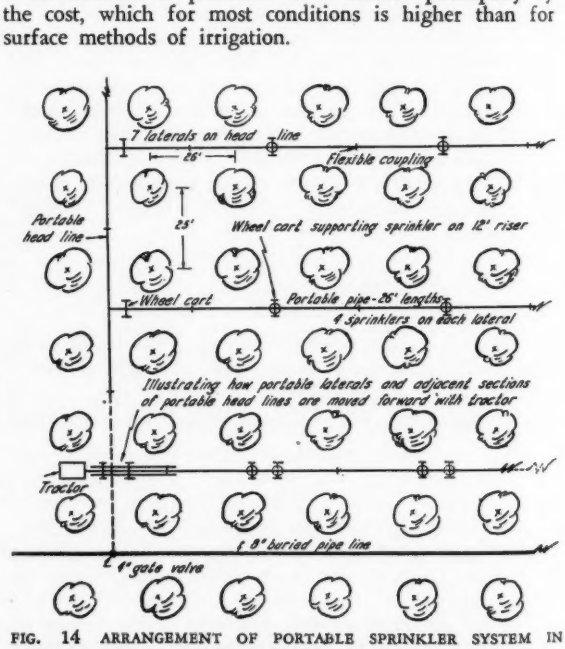

7 laterals on head line
25'
Flexible coupling
Portable head line
25'
Wheel cart supporting sprinkler on 12" riser
Wheel cart
Portable pipe - 25' lengths
4 sprinklers on each lateral
Illustrating how portable laterals and adjacent sections of portable head lines are moved forward with tractor
Tractor
8" buried pipe line
4" gate valve

FIG. 14 ARRANGEMENT OF PORTABLE SPRINKLER SYSTEM IN ORCHARD. CAN BE MOVED FORWARD, ONE LATERAL AT A TIME, WITH A TRACTOR

Terracing Extension Methods in Alabama

By J. B. Wilson

A MILD climate, with 50 in of rain and a system of row-crop farming, provides a splendid opportunity for an extension program in terracing. These conditions, however, are conducive to poor soil with low organic content, and necessitates heavy fertilizer applications. With these facts in mind it was decided that something for soil conservation had to be done, something that was decidedly different from what might be done in a cooler climate where freezing and lower temperatures prevailed over several months of the year.

With considerable experimental data on soil losses from rain, and a conviction on the part of farmers that something had to be done on account of land washing, an extension program in terracing was not hard to promote.

The method of attacking this problem is similar to other extension methods, except that a great deal of technical information has to be given to a large number of people in the position of assisting with terracing programs. This is accomplished through the medium of terracing schools. These schools came as the result of a demand for more information on the part of the farmers, and from numerous requests for county agents to design terracing systems for individual farmers.

COUNTY TERRACING SCHOOLS IMPORTANT LINKS IN SPREAD OF INFORMATION

The terracing school program calls first for a definite outline of what the duties of the specialists and county agents are. These were set out clearly in a plan for conducting the school. Sometimes a visit to the county for a conference with the county agent was found to be profitable because in such conference it was possible to work out the details for the school, and also to locate a field, as well as a classroom. Men from various communities were induced to attend this school on the basis that they were to return to their communities and assist their neighbors with their terracing problems. These men were, from the beginning, asked to make a demonstration of their own farms as a proof of their ability to do the work, and to place them in the proper light with their neighbors. Some of them did this, but far too many became only missionaries, talking the program without doing much toward actual terracing. This seemed to be due to the fact that the farmer had been getting his terracing lines laid out by the county agent free of charge, and was therefore unwilling to pay the terracer to do his work. As a result of this, the county agents had even more calls than before for laying out terracing systems. This frequently called for a second school within the county. During this time county agents realized that they must be relieved of laying out terracing lines. So when a farmer wanted assistance in terracing he must assure the county agent that he was going ahead with the construction of these terraces; that he had teams and the necessary equipment at hand for doing the work. The county agent then was able to go out and lay off one or two lines, and leave the farmer with instructions to go ahead with his building until he caught up with the lines. In many cases, it was found that the farmer went ahead of his own accord, after watching the first few lines laid out, and generally completed the job himself.

A new type of terrace, called the Nichols terrace, because Dr. M. L. Nichols conducted the experimental work, was used in demonstrations in several counties in 1929 and 1930. This gave a new interest to the terracing school and to the terracing program. These terraces were accepted wherever introduced and are now being built in every county of the state. It is the only terrace recommended by the extension service.

The greatest obstacle in this program was the construction of the new type of terrace. This work could be done with mule equipment, but it was extremely hard on teams, especially on cotton mules which are below the average in weight. Power equipment, of course, had long been recognized as proper for terrace construction, but how to put such equipment of sufficient size in operation, in sufficient numbers to do an effective job, was perplexing.

In training the men in terracing schools, certificates of achievement had been issued up until 1932. And, as previously mentioned, not all of the men receiving them were making a contribution to the terracing program. It was decided to discontinue the issuance of the achievement certificates until the trainee had proven himself worthy, which meant making a complete terracing demonstration of his own farm. This brought to a head the cooperative effort for doing terracing.

When Fletcher Farrington, county agent of Tallapoosa County, came to the close of his first terracing school, he told his farmers that certificates would not be issued until each farmer had made a complete demonstration of his own farm. These 16 farmers went home with the determination to do just that. They began with their own teams and homemade drags, which they had learned to construct during the terracing school. Mr. Farrington, of course, was keeping an ear to the ground to see what the results would be, and it was not long before he got a reaction that was not altogether acceptable. These farmers generally told Mr. Farrington that their mules were not large enough to do this job. Consequently, some other method had to be worked out if they were to keep their pledges to terrace their farms.

POWER TERRACING EQUIPMENT INTRODUCED TO MEET HIGH POWER REQUIREMENT

Power terracing equipment had been on demonstration at the college and had been discussed there for some time. Mr. Farrington, in his desire to meet this situation, had a talk with the salesman of a company building both tractors and terracing equipment, with the result that he was loaned a second hand 30-hp tractor and a terracer. Farrington announced a demonstration and the agricultural engineering specialist was present. Running out of gas, cracking a pinion, and rain made a failure of the first demonstration, but this was only a spur for a stronger effort and a demonstration was finally held which was considered an overwhelming success. It was not long, however, until it was found that this equipment was not

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers at Urbana, Illinois, June 23, 1937.

Author: Extension agricultural engineer, Alabama Polytechnic Institute. Mem. ASAE.

balanced. The terracing machine was too light for the tractor, and both the terracing machine and the tractor were too light for the heavy Piedmont soil. So the manufacturer, seeing the needs and possible demands, designed another terracing machine which was hitched to a new tractor of a larger size. This terracing machine proved to be too long and was topheavy. Another machine was designed and brought into the field. This seemed to be the answer and, as a consequence, other counties became interested until the whole of Alabama knew about this power terracing program. They also knew of the cost, which was extremely low, and people hunted for the means to start the program in their counties.

Limestone County, in the Tennessee Valley, started such a program by having their county commissioners underwrite the equipment. From these two counties the program has spread to 52 counties in the state, all having soil conservation associations, forty of which are incorporated. They are now operating over 100 power units. The power units include diesel tractors of 40 hp or larger and a terracing machine to match. Three or four different makes of terracers are operated in the state at the present time. Some of the counties are operating bull graders, heavy harrows, and subsoilers, in addition to terracing machines.

Another big problem with which we were confronted was man power to carry on educational and operations programs in the various counties. The extension service in most counties, of course, had only one man, the county agent, and with the inception of the AAA many problems arose which seemed likely to submerge the terracing program. However, it has stemmed the tide so far, and appears now to be on a better basis than it has since its beginning.

COOPERATING AGENCIES ASSIST TERRACING PROGRAM

Realizing this need for man power, it is needless to say we were proud when the Tennessee Valley Authority, the Soil Conservation Service, and the Rural Resettlement Administration became interested in this terracing program.

The Tennessee Valley Authority saw the possibilities of this power terracing program as part of a broad soil conservation plan, and through agreements, assistants who would be leaders for the operation of this equipment, as well as in the vegetative part of the program, were placed in each of the fifteen Tennessee Valley counties. This was heartening to the county agents and, as a result, fourteen of the 15 counties in the Valley secured terracing equipment and have carried on a program. Fourteen of these counties set a goal of 100,000 acres for 1936 and actually terraced 53,358. This work is continuing in good shape, with the exception that more training is needed in the efficient operation and care of the power equipment. M. A. Jones, the agricultural engineer in these counties, is working at this phase of the program and we are confident that this will be taken care of.

The U. S. Soil Conservation Service established an area in Tallapoosa County, in the Buck and Sandy Creek sections, which made another contribution to this program. Since then they have operated 12 to 15 power units in this area. Since the beginning of the program CCC camps were also established in many counties for cooperating with the county soil conservation associations, and have made considerable contributions in outlet controls.

The last expansion on the part of the Soil Conservation Service was in cooperation with the extension service, for the trial of what we term the expanded program. It was agreed that this would be tried in five counties where there were active associations and using power equipment. Two men were located in each county. One of these men placed in the county is an assistant county agent, financed jointly by the extension service and the Soil Conservation Service, and is responsible for the educational program. The other, an engineer, financed by the Soil Conservation Service, is called an operations superintendent. His responsibility is to supervise the job in soil conservation that the farmers are being trained to follow through the educational program. This seems to be the answer as far as the division of labor is concerned. It is also felt, however, that more than one man will be necessary to supervise operations which include more phases of the work than just terracing.

The Relief Administration cooperated with county boards of commissioners by assisting them in securing power terracing units, one for each of 21 counties. This was a method used in giving employment to people within the county, paid for by the county, and reimbursed by the purchase of the terracing unit. Later the Resettlement Administration made loans to county cooperatives for two of these terracing units, not necessarily as a financing proposition but for the purpose of helping with cooperative effort. One of these county cooperatives is proving to be a good financial proposition, while the other is still in the red.

TERRACING AS A FARM COOPERATIVE BUSINESS

At present, with a shortage of horse power and the immediate need for terracing, it seems that this program must be continued more definitely than ever. The farmers of the state know what this power terracing program can do. A very hearty feeling exists on the part of county courts in support of this program. The project has gone far as a demonstration. It is felt that we are now in a position to do terracing as a business cooperatively handled by the farmers. To this end the soil conservation association has been promoted. Better methods are being striven for and more information for the operator is being given, in order that equipment care and terracing design may be improved.

At this time the agricultural conservation program, with its payment of 40 cents per hundred lineal feet for terracing, is making it possible for the farmer to terrace his land without having to cripple his small cash income. It is hoped that this program will be continued in a way that farmers can reap this benefit until we at least have our good acres protected.

In order that terracing information could be properly disseminated, terracing schools were held during the past ten years in about 55 of the 67 counties in the state, for the purpose of training men to do this job. These men, with their county agents, have carried on and as a result we have a large, well-trained force, which last year terraced about 100,000 acres. This greatly supplements the 90,000 acres terraced with the farmers' own equipment. Cooperation with the TVA, the Soil Conservation Service, the Rural Resettlement Administration, and the Agricultural Conservation Administration has made it possible to broaden this service into a comprehensive, far-reaching program. Since the demonstrational phase of this program has reached the present point it seems necessary that county associations be perfected, that leaders must be trained to take over the operation and management of the work, and that this will eventually make for a terracing program that will do the job in Alabama.

Systems for Distributing Fuel Oil to Orchard Heaters

By F. A. Brooks

ORCHARD heating is now man's biggest effort to modify outdoor weather. Almost one-third of the entire citrus acreage now has heater equipment; a second third may in the future be equipped with heating systems, but the other third does not need heaters. Last January about 85,000 acres were heated to prevent frost damage, an acreage more than three times the land area of San Francisco City and County. About 2,000,000 barrels of fuel oil and 17,000 tons of solid fuel (coal, coke, wood, and rubber tires) were burned during approximately 15 nights from January 5 to 27, 1937. The gas-oil consumed in these three weeks amounted to about 4 per cent of the total United States annual refinery output of this grade of fuel. The available supply of coal or solid fuel is adequate for only a small acreage at the January usage rate of about 5 tons per acre. The cost of electrical energy is prohibitive at present for mass heating, and could not be widely used because the total sudden energy demand rate of about 30,000,000 kw would require nearly ten times the total electric plant capacity in all of California. It is clear, therefore, that, at present, fuel oil is the only major source of energy available for orchard heating. There are indications that to insure adequate supplies of fuel oil in the future, heaters should be developed to burn a grade of oil below the typical 27+ degree API gravity because modern refinery practice is converting more and more of this gas-oil into gasoline.

The storage in southern California of the usual marine diesel fuel, bunker grade, was inadequate last January, but fortunately large outgoing shipments were recaptured from tankers delayed by the longshoremen's strike. Additional supplies were obtained by tank trains, for which regular passenger trains were sidetracked. Nevertheless, local supplies were so depleted that there were reports of delivery trucks being forcibly deflected from intended destinations. The present shortage in storage capacity is being relieved by installations of tanks by the growers.

Although the total energy figure of 100 billion Btu per hour seems extravagant, it represents the requirement for producing a rather small modification of outdoor temperature, namely, raising the minimum night air temperature near the ground about 10 F (degrees Fahrenheit) for the area heated. The ground-level energy of winter sunshine, which is the primary power motivating the huge weather forces, is about five times that of the artificial heating practiced per acre.

The direct benefit of heating citrus orchards is indicated in the report of one grower who spent $1000 for wood and saved a $5000 lemon crop. The advantage of heating to the entire citrus industry can be visualized in the 35,000 cars of fruit saved at a time when about 30,000 other cars originated in unfrosted areas, and probably 35,000 car loads were lost in frosted areas due to lack of heating equipment or inadequate heating.

Considerable tree damage also was prevented. Hence, the financial saving of last January's orchard heating is no doubt more than $60,000,000. Against this there is the direct heating cost of about $7,000,000 and an undeterminable smoke damage, estimated at $2,000,000 for merchandise and $4,000,000 to $5,000,000 damage to homes in the Los Angeles metropolitan area[1]. Incidentally, new heaters selling at from $3.00 to $4.50 each, when properly operated do not produce visible smoke, but most of the 3,500,000 heaters now in the field are smoky.

The January 1937 freeze was exceptional. No comparable cold weather had been experienced since 1913. Growers found the usual methods of regulating, cleaning, and filling heaters were inadequate, and the public protested vigorously against the smoke. The division of agricultural engineering of the University of California had previously studied the smoke output of orchard heaters[2] and so was called upon in March to make an emergency study of orchard heating as a whole and to issue recommendations by midsummer for the guidance of growers who were purchasing orchard heating equipment for this coming winter.

The major difficulties encountered by growers during the exceptional cold spell of January 1937 were studied in three investigations, namely, heater operation, fuel characteristics, and fuel distribution to heaters in the field. The

Presented before a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Asilomar, California, October 16, 1937.

Author: Associate agricultural engineer, California Agricultural Experiment Station. Mem. ASAE.

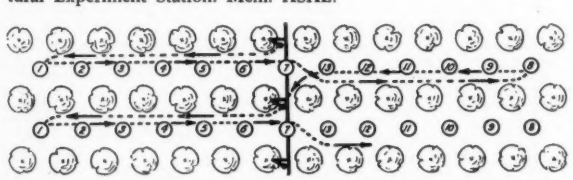


FIG. 1 A SUGGESTIVE WORK PATTERN FOR FILLING HEATERS WITH A 100-FT, ¾-IN HOSE LINE, WHERE THE HYDRANTS ARE PLACED IN EVERY ROW AND HEATERS ARE ARRANGED BETWEEN ROWS OF HEDGE-ROW PLANTINGS

[1]From a statement by H. C. Legg of the Los Angeles County Board of Supervisors at a meeting in Covina, February 5, 1937.

[2]"The Smokiness of Oil-Burning Orchard Heaters," by Warren Schoonover and F. A. Brooks. Calif. Agr. Exp. Sta. Bul. 536 (1932).

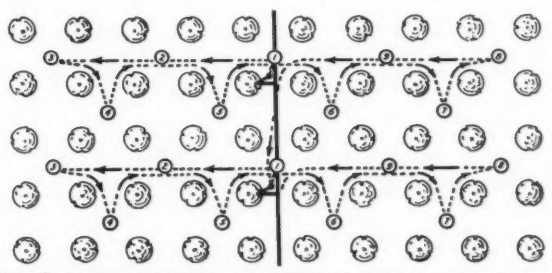


FIG. 2 A SUGGESTIVE WORK PATTERN FOR FILLING HEATERS WITH A 90-FT, ¾-IN HOSE LINE, WHERE THE HYDRANTS ARE PLACED EVERY OTHER ROW, WITH HEATERS BETWEEN ROWS PLACED EVERY OTHER TREE AND STAGGERED

oil generally used for orchard heating is also used extensively for other purposes. Hence, the section of the report dealing with fuel distributing systems for orchard heaters may contain engineering information of more general interest.

Although the distribution of 2,000,000 barrels of oil to the various ranches is a considerable transportation problem in itself, this study of fuel distribution was confined to that of getting the oil from the ranch storage into the individual heaters, 22 to 100 per acre. The ground is often very muddy when the refilling must be done, since the typical radiation frost (due to rapid cooling of the ground surface by radiation to the cold sky) often follows a rain. Furthermore, it is usual practice to have the ground furrowed for irrigation and bearing a cover crop. These environmental factors seriously impede any filling technique, and because trucking over wet ground injures the soil structure, tank-wagon driveways are restricted, and most filling of heaters has been done by hand with 5-gal buckets.

The usual procedure is to drive a tank truck or wagon of about 400 to 500-gal capacity through the orchard every few rows, filling the heaters by pails (usually carried two rows each side), or by a 1½-in hose about 20 ft long filling only the near heaters, or by a combination of pails and hose. The filling rate per hour averages about 150 gal per man. Under favorable conditions this rate has been more than doubled (the men running on return trips with empty buckets). However, during the January freeze the filling was very heavy work, heaters often had to be filled while burning, and because the men had almost no rest night or day, the manual filling operations practically failed on the third successive day. Fortunately the night temperatures rose somewhat then, and the rate of burning was reduced, which eased the need for refilling. There were repetitions of such periods of severe two to three-night frosts during the January cold spell.

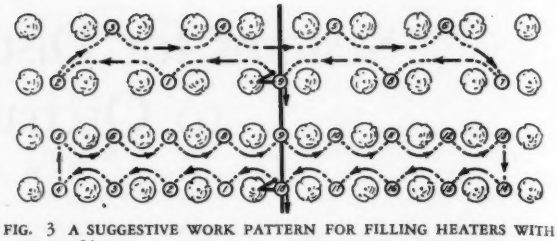
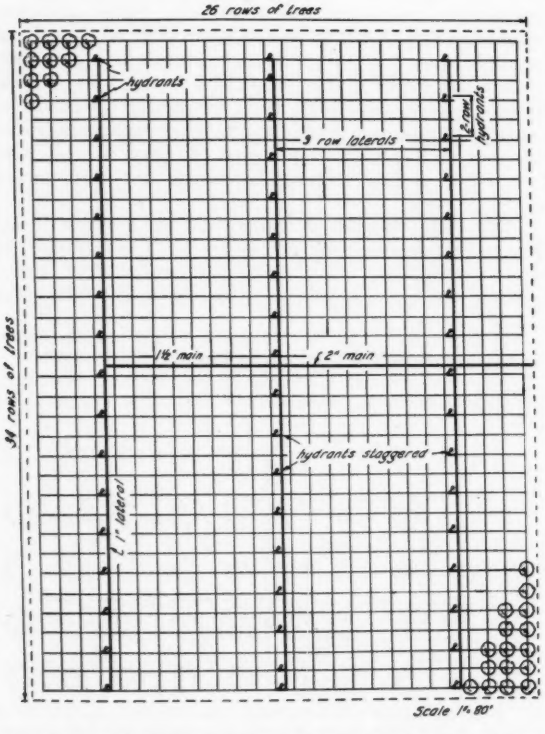


FIG. 3 A SUGGESTIVE WORK PATTERN FOR FILLING HEATERS WITH A 90-FT, ¾-IN HOSE LINE, FROM HYDRANTS IN EVERY SECOND ROW WITH (A) HEATERS PLACED IN THE ROW, EVERY OTHER TREE AND STAGGERED, AND (B) HEATERS PLACED IN THE ROW, WITH A HEATER FOR EVERY TREE

Considering the troubles with tank wagons and the heavy work of carrying pails of oil over muddy ground, the most promising improvement seemed to lie in piping the fuel oil from the ranch storage tank to well-placed hydrants from which all heaters could be reached by hose, or even piping direct to each heater.

A brief investigation of hose-filling operations showed that filling was much faster with one man with a short hose than with two men on a long hose. A ¾-in hose of 100 ft was plainly the most any one could handle effectively, and then only if the pattern followed was straight and with no danger of displacing heaters while dragging the hose from one location to another. Fig. 1 shows the first problem in hose handling. Assuming that in the first row heater No. 13 has just been filled, the first move is to uncouple from the first hydrant. Next, both hose ends are dragged to the second hydrant and the hose recoupled. The loop in the middle of the hose still lies near heater No. 11, so the entire length of hose must be dragged to the new extended position to reach the second row heater No. 1. Then in filling heaters 1 and 2 and 3, and so on to 7, a half-length of hose is the maximum that must be dragged,



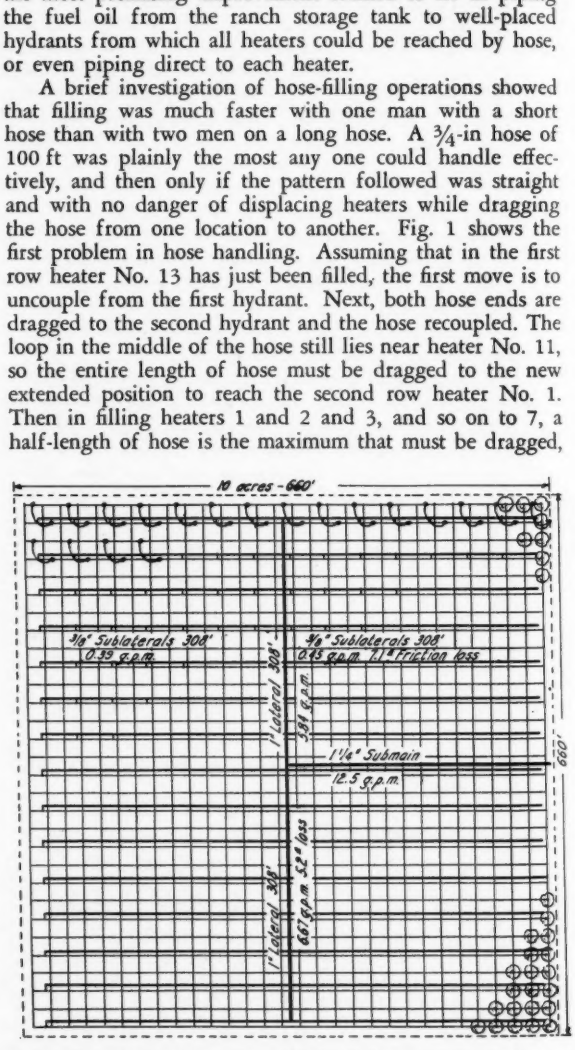


FIG. 4 (LEFT) HYDRANT PIPING LAYOUT FOR 9-ROW LATERALS, TWO-ROW HYDRANTS, WITH TREE SPACING 22x22 FT. FIG. 5 (RIGHT) PIPED HEATER SYSTEM LAYOUT FOR ORCHARD HEATERS IN EVERY ROW, SPACED EVERY OTHER TREE AND STAGGERED. FLOW, 75 GAL PER ACRE-HOUR, 0.0556 GAL PER MIN PER RISER (2 HEATERS); 45 HEATERS PER ACRE, TREE SPACING 22x22 FT

and this minimum drag speeds up the filling process. After filling No. 7, the hose is again dragged out full length on the other side, and in order to clear heater No. 13 of the second row on moving to the third row, the hose must be stretched along the downside of the heaters. The crossing-over is likely to move No. 7 unless this heater is placed out of line or staked.

For square planting and staggered heaters the hydrants might well be placed every two rows and the pattern shown in Fig. 2 followed to avoid heater-hose interference. A rate of oil flow of 10 gal per min is easily managed and about half the time would be spent in moving from heater to heater. The fuel output per man with this system is estimated at about 325 gal per hr. Fig. 3 shows the modification of pattern to suit heater locations in tree rows often practiced to leave lanes free for other orchard operations. A typical tract layout for nine-row hydrants is shown in Fig. 4. The material cost for such a hydrant system is about $100 per acre.

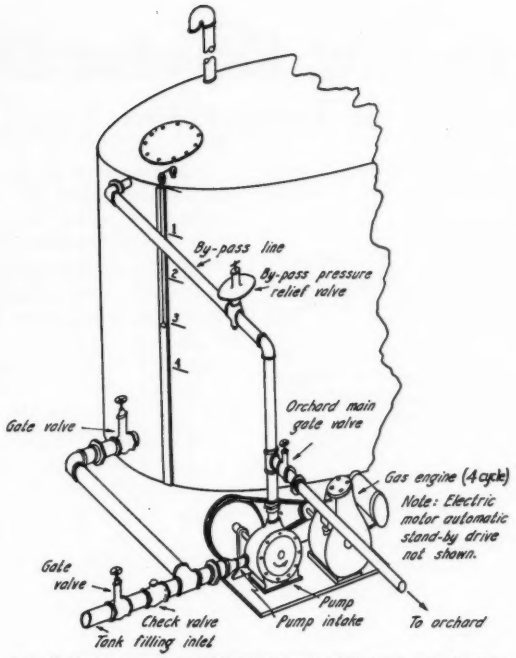


FIG. 6 DIAGRAM OF CONNECTIONS AND FITTINGS FROM ORCHARD PIPE SYSTEMS TO PRESSURE PUMP AND STORAGE TANK

Piping each heater, as is necessary for pressure-generator types and drip heaters, requires different design criteria from those customarily employed in the layout of fire-protection sprinkler systems, water service networks, etc. A similar uniform distribution of pressure is wanted over the network area, but in orchard piping systems this should be true coincidentally with a uniform discharge rate from each small terminal. Ideally, the whole area should be laid out in multiple-H formation to make the length and size of pipe run identical to each terminal. This is practically impossible and previous practice varies from single $\frac{3}{8}$-in pipe lines 800 ft long, to single-stepped lines starting at $1\frac{1}{2}$-in and ending at $\frac{1}{2}$-in at 660 ft.

The maximum rate of fuel demand is about $1\frac{1}{4}$ gal per acre-minute for oranges with 45 to 50 heaters per acre. This rate, considered with a maximum viscosity of 120 sec Saybolt Universal, indicates laminar flow in all terminal pipes. Some difference in pressure at heaters can be adjusted for by the needle valves and differences up to 50 lb per sq in are in use. Obviously a design would be desirable in inverse proportion to maximum pressure differences, so other primary criteria were sought instead of pressure difference limits.

To connect every heater with a pipe requires such large quantities of pipe that the greatest lengths should be of minimum cost. This pointed at once to the $\frac{3}{8}$-in size, since it was the same price as the $\frac{1}{4}$-in, unquestionably more suitable than $\frac{1}{8}$-in (which was only slightly cheaper), and yet much cheaper than the $\frac{1}{2}$-in. Calculations showed only 10-lb pressure losses with typical use rates in lines up to 400 ft long. Acceptance of this pipe size as basic for the terminal network then brought the question as to the size and length of the lateral. This decision seemed to be related to questions of orchard tract management.

Many individually owned citrus orchards are of 10, 15, and 20 acres each and tract management often uses area units of 10 acres. That size area makes a convenient unit block size for which we could consider the fuel source at the center (pressure here governed by a regulating valve if necessary). Fig. 5 shows a typical 10-acre piped heater layout that seemed sufficiently reasonable and practicable for us to recommend the unit block system for all piping layouts. It is to be noted that at maximum burning rate for oranges and assuming maximum viscosity, the greatest difference in pipe-end pressure is only about 12 lb per sq in. Hence, under usual operating conditions with 90-sec oil, the pressure differences will be relatively negligible, especially if there is the much larger friction loss expected at the control valve of each heater. Material cost for such a system is about $200 per acre.

Having established the block area unit design, it is then merely a question of hydraulics to work out a complete system for any orchard. First, the unit areas must be chosen with due regard to cold pockets, topography and existing orchard management sections. The $\frac{3}{8}$-in lines usually follow irrigation furrows. The laterals should cut across the center of the block, but if there is sideslope, these should be shifted uphill to give uniform terminal pressures. Practical departures from ideal main locations should be made to follow existing roads. All risers and surface pipes should be located for minimum interference with orchard practice. Storage tanks, preferably on high ground, must be located near all-weather roads to avoid expensive pipe and pumps for unloading the tank trucks at the specified rate of 6000 gal in 2 hr. For gravity systems, the head is usually limited, but sloping ground often makes it possible to avoid pressure regulators at unit block sources if the firing procedure is regular. A few large gravity systems are now being installed, the operation of which should be carefully observed this winter.

Where the line flow depends on pumping, there is at first glance a wide range of pressures to select from. Practically the pump pressures should be below 100 lb per sq in to avoid high pump costs and pipe troubles. For the relatively low rates of flow involved, this limitation of pressure does not require unduly large mains for the areas covered. A few pumping features, shown in Fig. 6, need special attention to safeguard the continued operation of a pump pressure system. First, a dual drive is essential because local electric power may be off due to a storm preceding the frost, or the gasoline engine may be hard to start in subfreezing weather after a long period of non-use. Valveless, positive rotary pumps are preferred for reliability after non-use. The by-pass line from the pressure relief valve must be returned to the storage tank to avoid pump troubles due to fast recirculation of the entire flow before many heaters are fired. And, finally, line filters are needed to protect pressure regulators and needle valves from sludge.

A Simple Low-Cost Drawbar Dynamometer

By Andy T. Hendrix

THERE are various uses to which a drawbar dynamometer may be put, but probably the greatest need and application of the device is in the study of power requirements of tillage tools. There is a great difference in the power requirements of the many types of tillage tools now available. Even with the same tillage machine, so many variable factors are encountered that requirements vary considerably.

One of the factors which most affects power requirements in tillage is that of soil type. Little information is available on requirements of the various types of soil in Tennessee, especially as regards the power necessary for tillage of these soils under various conditions.

To secure this information, a project was proposed at the University of Tennessee by the author in the spring of 1936. In order to conduct this work, a drawbar dynamometer was essential. Of the various types of dynamometers available, none was considered sufficiently simple in construction and low in cost to enable us to obtain one. Also, the available pressure units were not considered wholly satisfactory in performance. We therefore decided to attempt the design and construction of a dynamometer pressure unit which would more nearly meet our needs. The characteristics which we considered most essential were:

1 Ease of application to almost any type of farm implement.

2 Light weight, simple construction, and durability.

3 Sufficiently sturdy in construction to withstand loads of 4000 lb or more, combined with sufficient sensitivity to register small variations in load.

4 Small size, with short coupling space.

5 Adaptability to either direct reading or recording.

6 Low cost of construction.

Author: Assistant professor of agricultural engineering, University of Tennessee. Mem. ASAE.

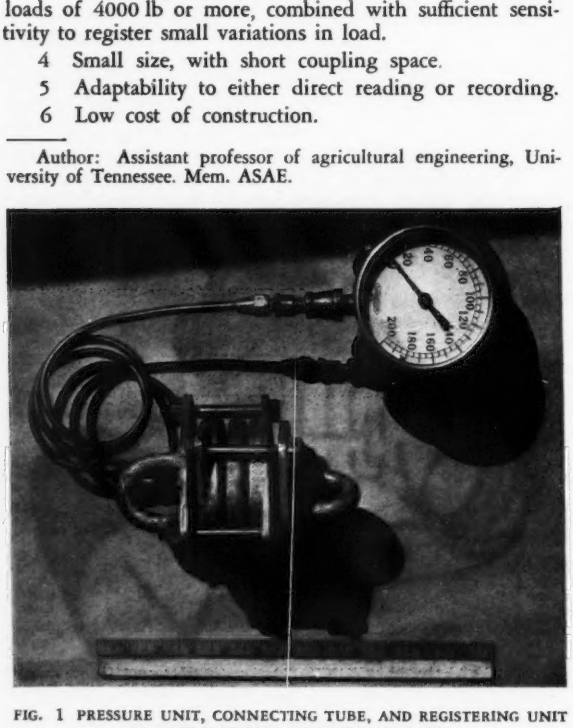


FIG. 1 PRESSURE UNIT, CONNECTING TUBE, AND REGISTERING UNIT OF LOW-COST DRAWBAR DYNAMOMETER

Since none of the present known types of dynamometer pressure units met the requirements above listed, it was decided to depart from any of the known designs and approach the problem from a new angle.

The idea finally adopted for the design of the pressure unit was that of a semiflexible steel bellows as shown in Fig. 1. As indicated in this picture, the unit is extremely simple and compact. It is only 7 in long overall, and weighs 7½ lb when filled with fluid, yet it will withstand the greatest drawbar pull of the average farm tractor and still have a large factor of safety.

An assembly drawing of the pressure unit is shown in Fig. 2. The cost of construction of the unit is low as compared with most similar devices, there being no accurate machine work necessary. The various parts are cut roughly to size and are then welded together as indicated on the drawing.

When completed, the pressure unit is filled with liquid, care being exercised to insure the absence of air pockets or bubbles. The registering unit and connecting tube shown in Fig. 1 are then carefully filled and attached to the pressure unit.

Any type of pressure gage may be used, provided it has a suitable pressure range for the load in question. As shown in Fig. 1, an ordinary pressure gage may be used if only instantaneous readings are desired. For complete records, a recording gage unit must be attached to the pressure unit. The recording unit must be mounted in such a manner as to avoid errors due to vibration and other transportation effects. Little experimental work has been done here on this phase of the problem, because very satisfactory methods have been developed at other institutions to accomplish this purpose.

The complete dynamometer consists essentially of three parts; namely, the pressure unit, the connecting tube, and the registering unit. The recording or registering unit of the device is attached to the pressure unit by metal tubing, preferably flexible, which may be of almost any convenient size and length. This tubing, pressure unit and gage unit must all be completely filled with suitable liquid. At a convenient location in the line of tubing, there is placed a restricted passage and a small reserve liquid reservoir, not shown in the illustration. The restricted passage serves to dampen the effects of sudden loads and vibrations, and maintains a more uniform reading on the registering unit. The liquid reservoir is sealed into the system and serves either to *(Continued on page 546)*

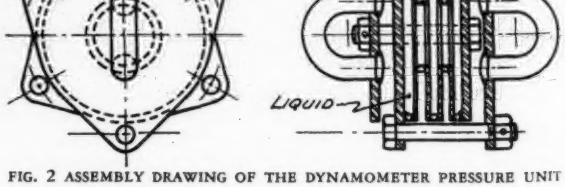


FIG. 2 ASSEMBLY DRAWING OF THE DYNAMOMETER PRESSURE UNIT

Organization for Promotion of Better Farm Building

By K. J. T. Ekblaw

THE FARM Structures Division of the American Society of Agricultural Engineers is, in my opinion, the place to which we should look for real leadership in the improvement of farm buildings. The need for farm building is fundamental. The physical need for shelter for the farm owner and his family, for his crops and for his animals, has always been recognized. Now a new need is developing which might be called the economic need, or the significant relationship which buildings bear to economical farm management and production.

We must recognize at least three important phases of the whole subject of farm building construction: (1) Planning the buildings for comfort, convenience, efficiency, and economy; (2) the labor, skilled and unskilled, which translates the paper plans into reality; and (3) the materials themselves.

Better farm buildings mean better planning, better use of labor, and better materials. As agricultural engineers, we are interested in all these things, and all of them should be carefully considered and acted upon if we are to get maximum results.

I desire to propose the bare elements of a plan through which I believe it is possible to get results. Simply proposing a plan, however, is not enough; we must put that plan into operation. My suggestion is a simple one: Get together representatives of all who are interested in better farm buildings. I would include farmers who recognize the value of well-planned, well-constructed buildings; college instructors who teach the how and why of better buildings to their students; extension men who advise farmers in regard to their buildings; dealers who sell the materials and the producers, processors and mass sellers of building materials and equipment.

Get these representatives together, provide for well-planned, well-directed, intelligent discussion. Let every industry be properly represented. Let the discussion be frank and straightforward. All this effort is to be directed toward a definite object and that is to develop, at the close of such a conference and as a result of all the information and opinions that will be expressed, a plan of real action or of real organization for action.

I am reluctant to go very far in suggesting the details of a plan for the promotion of better farm buildings, but I believe that there are examples of promotion organization already existent in other fields of agricultural engineering which we can profitably study. I refer particularly to the Farm Equipment Institute and the Edison Electric Institute; there may be others. Whether the set-up of these organizations would be the best for farm structures, I am not ready to say, but these two at least seem to be working on a practical and successful basis. No one can say that agriculture has not profited from the interest which these organizations have taken in the industry.

Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers, at Urbana, Illinois, June 22, 1937.

Author: Agricultural engineer, American Zinc Institute. Mem. ASAE.

The development of a somewhat similar type of organization in the farm structures field should not be very difficult if all those who are interested in the project will get together with open minds and unselfish intentions. The ultimate objective, the improvement of farm buildings, should be the thing that should be kept constantly in mind; and with this high and unselfish ideal maintained, the ways and means of attaining the ultimate objective will naturally be satisfactory.

One of the most essential things in any successful plan for the improvement of farm buildings is provision for proper merchandising of the materials. Unless this be included in the plan, the interest of commercial organizations can not be aroused. Commercial concerns that may be represented in the general conference which I have proposed, may properly take the responsibility for merchandising and sales promotion, but even so, these two phases of any successful plan must be recognized and understood by everyone.

So far as the American Society of Agricultural Engineers is concerned, its function is of course fundamentally engineering; but engineering includes both pure and applied science, and when you come to applying science you have to cover the whole distance from beginning to end, from the production of the raw materials to the use of the finished product, including its merchandising and distribution. Engineering must go along every step of the way, and the more completely agricultural engineers follow the route, the better it will be for them and for everyone concerned.

It may be said that there are already organizations of commercial concerns working along the lines we have projected. True, there are building material associations set up all over the country and their membership includes not only dealers but producers and processors of materials, suppliers of equipment, etc. There are also organizations that supply plans. There are manufacturers' organizations, traffic organizations, credit organizations, etc. The very fact that these organizations already exist should make it easier to effect an organization such as I am suggesting; representatives from these organizations should be able to give us very valuable advice and suggestions.

As I visualize it, the operation would be somewhat as follows: Intelligent farmers would inform agricultural engineers of their requirements; these engineers would work out these requirements into efficient plans; producers and processors of materials would advise the engineers of the materials that are available; if the engineers could not find the kind of material that was needed, or if they felt that some new material should be developed, they would so inform the producers and processors and perhaps outline the ways and means by which such materials might be developed; research engineers would make fundamental studies of farm building needs and not only help the producers of materials satisfy these needs but help in their distribution for the benefit of agriculture. In other words, engineering, research, extension, production, and distribution should all go hand in hand.

Will industry support such a move? In my opinion I believe it will. During the last ten years I have discussed this very subject with representatives of various industries that might have an interest in farm structures, and I have never met with anything but approval of the idea. The great producers and converters of lumber; the numerous manufacturers of portland cement; the widely scattered manufacturers of clay products; the dozens of steel mills; paint manufacturers; insulation manufacturers; manufacturers of equipment for farm homes and for other farm buildings—all of these should be, and I believe are, interested in a project of this kind and will cooperate in its advancement.

What we as agricultural engineers specially interested in farm structures must see to, is that attention is diverted to the tremendous importance of this particular subject. The farm market, like every other market, is being tremendously exploited. Fair enough: That's only good business; but let me make some quotations from a letter which recently came to my office.

"While thousands of farmers ride in new automobiles or on new tractors, listen to a new radio, or enjoy many other new things, their farm buildings are in a frightful state. They need repair, modernization or replacing. They need concrete work, paint, lumber, builder's hardware, insulation, barn equipment; yet these important needs come last—are filled after other desires are satisfied, if there is any money left."

The above quotation perhaps indicates a rather biased view of the project, but let me make a further quotation that shows it is not entirely selfish.

"As individual companies, interested in farm building activity, we can't do it alone. We just can't compete with the automobile, implement, and radio people, just to mention a few. They're too big and are getting more than their share of the farmer's dollar. However, an association of the cement, lumber, paint, insulation, barn equipment people, and others could accomplish much in the way of education, advertising, publicity, and promotion. Such an association could see that many millions were put into farm building construction and remodeling. Perhaps we could help teach farmers to make profit-taking buildings into profit-making buildings, so they could better afford the luxuries and non-essentials."

As agricultural engineers, are you ready for action? Do you believe that a basic need exists for better farm buildings? Is there not a probability that a good part of the enormous amount of farm income spent for non-essentials should for reasons of good management be diverted into farm building construction and rehabilitation?

Someone must take the lead in this movement. Agricultural engineers are logically the group to do it. If the opportunity is faced now, it will be to the great ultimate advantage of agricultural engineers.

A Simple Low-Cost Drawbar Dynamometer

(Continued from page 544)

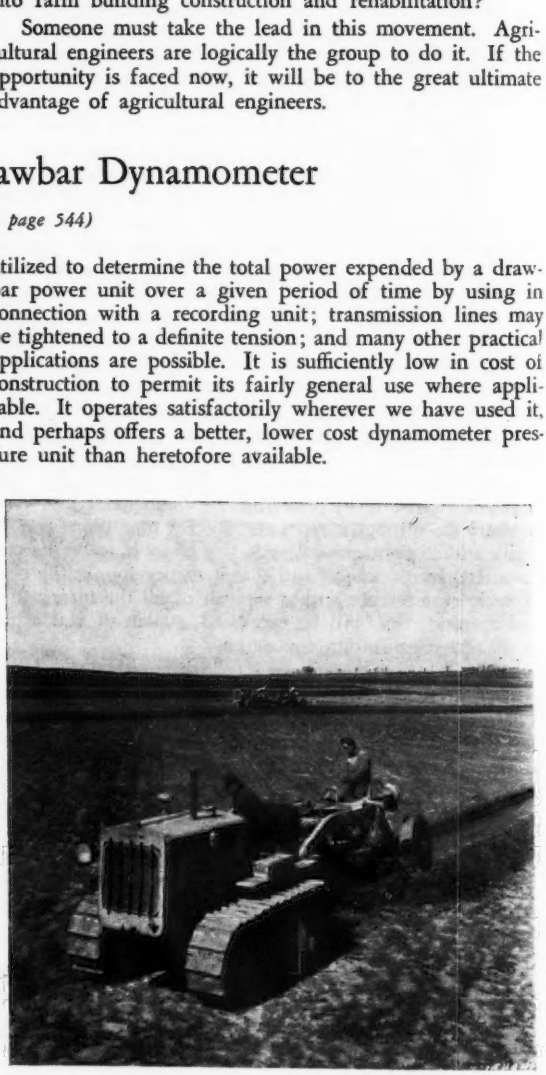
increase or decrease the amount of liquid in the unit, as necessary to adjust for zero reading.

When in operation, load is applied at each end of the dynamometer pressure unit through the U-bars shown in Figs. 1 and 2. The liquid in the unit is then under compression, but being practically incompressible, the pressure is transmitted through the tubing to the registering unit. The system is completely sealed. The actual flow of liquid through the tubing is very slight when the device is operating under load. Since there are no moving parts in either the pressure unit, tubing, or registering unit, no appreciable flow of liquid within the device, and no great friction-producing distortion of the pressure unit, there are necessarily only negligible friction losses. The applied load is therefore accurately transmitted to the registering unit as unit pressure. The accuracy and sensitivity of the device is determined and limited only by the accuracy and sensitivity of the recording unit. There are no pistons, no packing, no glands, and consequently there is no leakage. The system being completely sealed, there is no tendency for leaks to occur as a result of use and wear.

A unit was constructed and was calibrated by loading with known weights. The ratio of load to gage reading was constant, and the calibration curve is a straight line. Under a loading of 2,000 lb, the pressure unit was compressed less than 1/16 in from no-load position.

A pressure unit similar to that shown in Fig. 1 was loaded to the rupture point which occurred at over 15,000 lb. This indicates a high factor of safety for the unit, even when constructed of materials as light as shown by Fig. 2.

This drawbar dynamometer pressure unit may be used in the same manner as any other similar unit, but with less error, less inconvenience, and less cost. It may be utilized to determine the total power expended by a drawbar power unit over a given period of time by using in connection with a recording unit; transmission lines may be tightened to a definite tension; and many other practical applications are possible. It is sufficiently low in cost of construction to permit its fairly general use where applicable. It operates satisfactorily wherever we have used it, and perhaps offers a better, lower cost dynamometer pressure unit than heretofore available.



Spontaneous Heating and Ignition of Hay

By Harry E. Roethe

THE SPONTANEOUS ignition of hay causes fire losses on farms in the United States of millions of dollars annually. In addition to these losses there is the enormous loss in feeding value of hay which results from the abnormal spontaneous heating of undercured hay in storage, without the production of temperatures sufficiently high to cause ignition. This loss is perhaps as great or even greater than the fire losses.

Semi-Large-Scale Experiments. Supplementing investigations in the laboratory on chemical and microbiological problems of the spontaneous heating of hay, a series of semi-large-scale experiments[1], eleven in number, was undertaken by the Bureau of Chemistry and Soils and continued over a period of several years. These experiments were inaugurated in order that some of the causes, effects, and methods of prevention of spontaneous heating of hay might be investigated under conditions that were believed to be conducive to excessive heating, and which might prevail in the storage of hay on farms.

A wooden barn, isolated from other structures, was erected for and used in these experiments. The inside dimensions were approximately 24x26 ft, and the height from the floor to the ridge of the roof was about 22 ft. The siding and the gambrel roof were covered with heavy roll roofing. A single ventilator was installed on the ridge of the roof, at the center. The flooring was tongued and grooved. Limited working space inside the barn was provided by a 3½-ft alley at one end of the mow. A small lean-to, in which the apparatus for reading temperatures was located, was built later at one corner. The capacity of the mow was 20 to 50 tons of long hay, depending upon the moisture content of the hay and the degree of packing. The barn was equipped with a harpoon fork and overhead track for filling the mow.

For most of the experiments the hay was principally alfalfa obtained from nearby farms. In several of the earlier experiments, however, the hay was grown on the U. S. Department of Agriculture farm, and in 1930, a year of severe drought, baled alfalfa hay from Ohio was used. Most of the alfalfa hay was of good quality and would have been graded as either No. 1 or No. 2 leafy. The hay was placed in storage with a moisture content falling within a desired range. This was accomplished by periodic moisture determinations in the field and by retarding or accelerating the curing of the hay as required.

In some experiments the mow was filled uniformly with hay of the desired moisture content; in others it was made up of several strata, each of a selected moisture content, and in still others undercured hay was placed in a central section with cured hay surrounding it.

In two of the eleven experiments well-cured baled alfalfa was placed in storage after the bales had been broken up and the hay loosened. As the dry hay was scattered in the mow, it was sprinkled with water to bring the moisture content of the mass within the desired range.

During filling operations, in each experiment, zones were established at various levels in the mow, and thermocouples were placed at selected locations in each zone for the determination of temperatures. Provision was made for the collection of samples of hay and of gas from the interior of the mow, and for the introduction when desired of measured quantities of air or oxygen into the mass of hay during the progress of the experiments.

In eight of the eleven experiments the losses of organic matter during storage were determined upon samples of the hay contained in baskets or pillows made of wire cloth and placed at selected locations in the mow. A thermocouple was imbedded in each sample of hay. The baskets and their contents were carefully weighed when they were placed in the mow and again when removed. Moisture determinations and chemical analyses also were made of these samples at the beginning and at the end of the experiment.

The duration of individual experiments varied, depending upon the degree of heating and other factors. The shortest time that the hay was left in storage was five weeks; the longest, seven and one-half months.

Upon the termination of an experiment and when conditions warranted, successive vertical sections were cut in the hay and removed for the study and observation of the exposed strata. When this procedure was not followed, the hay was removed as evenly as possible from the entire horizontal surface of the mow by means of pitchforks, and weighed. Samples of the hay were collected from the various zones for subsequent examination or analysis.

The maximum quantity of hay used in any one experiment was 48 short tons; the minimum quantity was 14 tons. The highest moisture content of hay placed in the mows was 60.2 per cent, the lowest 9.6 per cent. The moisture content of the basket samples previously referred to varied somewhat from this maximum and minimum.

General Experimental Results. The maximum temperature produced in any experiment was 88 C (degrees Centigrade). This temperature was reached in the mow composed of baled alfalfa hay containing 15.2 per cent moisture which was sprinkled with water to bring the average moisture content to approximately 50.5 per cent. The tonnage of this wetted hay was 48. Maximum temperatures in the series of experiments were generally reached within five to nine days after the hay was placed in storage.

Hay of a distinct brown color did not result if the moisture content of the hay as stored did not exceed approximately 30 per cent.

Investigation[2] of the losses in weight of samples of undercured alfalfa in metal baskets stored in the mows demonstrated the seriousness of the losses of organic substance caused by spontaneous heating. The greatest losses occurred in the two experiments in which the average

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Presented before the Farm Structures Division at the annual meeting of the American Society of Agricultural Engineers at Urbana, Illinois, June 24, 1937.

Author: Senior engineer, Bureau of Chemistry and Soils, U. S. Department of Agriculture. Mem. ASAE.

[1]Associated with the author in these experiments were E. J. Hoffman and M. A. Bradshaw of the chemical engineering research division, E. D. Gordon, formerly of this division, and L. H. James, L. S. Stuart and E. A. Beavens of the food research division, U. S. Bureau of Chemistry and Soils.

[2]"Losses of Organic Substance in the Spontaneous Heating of Alfalfa Hay." E. J. Hoffman and M. A. Bradshaw, Journal of Agricultural Research, vol. 54, no. 3: 159-184. 1937.

moisture content of the hay was slightly more than 30 per cent, but in which a large proportion of the hay was undercured hay of much higher moisture content. The maximum loss in these experiments was approximately 22 per cent, the average loss nearly 14 per cent; but these losses probably do not indicate the full extent of loss, because much of the undercured hay had been so severely affected as to render it of very little value for feeding purposes. In neither of these experiments did the maximum temperature exceed 78 C.

FOOD VALUE LOSSES CAUSED BY OXIDATION

The losses were much less in the one experiment in which the moisture content of all the hay approximated that of normally cured hay. Here the maximum loss was approximately 8 per cent, and the maximum temperature produced was 56 C.

Losses in organic substance were found to involve chiefly the fats, the sugars, and the hemicelluloses, while there was a further loss of protein, and cellulose under the more destructive conditions. Evidence was obtained of the partial or complete destruction of carotene, the precursor of vitamin A, which is an essential constituent of alfalfa hay of good nutrient quality.

Results[3] of the investigation of gases formed in the mow undergoing spontaneous heating, interpreted in the light of the results of laboratory experiments on the absorption of oxygen by alfalfa hay under the influence of heat supplied from external sources, indicate that, along with the respiration processes of the living plant cell and the activity of micro-organisms, chemical oxidation also occurs throughout the whole range of temperature usually ascribed to biological agencies. The results further lend support to the view that in the spontaneous heating of hay unsaturated, easily oxidizable substances are formed, whose oxidation would partially account for the ready consumption of oxygen with the resultant production of heat.

Analysis of the samples of gas collected in these experiments in which maximum temperatures of 56 to 88 C were reached, failed to show positively the presence of any combustible or spontaneously flammable gas, although in several samples from one mow the occurrence of very small quantities of carbon monoxide and hydrogen was indicated.

Owing to the action of heat, water vapor, gases, and the organic acids formed by oxidation of the hay, very serious corrosion of certain base metals and alloys occurred in the mow. Iron-constantan thermocouples and wires, iron pipes, monel metal wire cloth and silver-plated monel wire cloth rapidly disintegrated, and aluminum pipes were seriously attacked. Chromel-alumel thermocouples and wires, however, were found to be very resistant to this corrosive action, and Nichrome IV wire cloth stood up satisfactorily.

Compartment Storage. In two experiments one corner of the barn was partitioned off with wooden studding to form a small mow with two exposed sides, having a capacity of approximately 15 tons of long hay. The studding consisted of upright two-by-fours spaced 2 ft on centers. In eight other experiments similar studding was used to provide the mow with one exposed side.

Judged by its color and general appearance at the termination of each of these ten experiments, undercured hay within approximately 6 ft of an exposed side, in most cases had not undergone severe self-heating. Even when this hay had an original moisture content as high as approximately 35 per cent, it was found to be of good quality at the end of the storage period. These facts indicate that exposure of the hay on one or more sides of the mow facilitated the dissipation of the heat produced and the drying out of the mass. The division of large mows into small compartments by means of alleyways or open-work partitions should aid materially in the accomplishment of these results in the storage of long hay in barns. Each compartment should not be over 12 ft, or possibly 14 ft, wide with at least two exposed sides paralleling each other.

Use of False Floor. In four of the eleven experiments the stored hay was elevated a short distance from the barn floor by means of an open-work support of wood which it was anticipated would increase natural aeration of the hay. This false floor consisted of two-by-eights which were laid on edge on the barn floor, and spaced approximately 3 ft on centers. Two-by-fours were laid (on edge) transversely on the two-by-eights, and spaced 5⅝ in on centers (4 in between sides). The two-by-eights were held in place by cleats at each end and were notched so that the two-by-fours fitted into them, thus providing a flush top surface. Since the actual size of a two-by-four is 1⅝ by 3⅝ in, and that of a two-by-eight is 1⅝ by 7½ in, the hay rested 7½ in above the barn floor and the clearance between the floor of the barn and the bottom of the two-by-fours was 3⅞ in.

The studding on the one exposed side of the mow was equipped at the floor level with close-fitting sliding boards by means of which the open end of each channel under the hay formed by the two-by-eights, could be closed if desired.

VENTILATION VALUE OF FALSE FLOOR TESTED

In the last of these four experiments the mow was divided into two compartments of equal size, 12 ft wide and 23 ft long, separated by a partition of two-by-fours covered on each side with insulating board ⅞ in thick. The false floor was placed in but one compartment. The two mows were built up jointly with first-cutting, long alfalfa hay, the first load being placed in the unventilated compartment, the second in the ventilated compartment, and so on. Uniformity of hay in the two mows, with respect to moisture content and quality, was sought by the following loading procedure in the field: The hay was cocked and loaded by hand on two trucks at a time, one following the other, and taking alternate cocks from two rows. From June 2 to 6, 1936, 27,920 lb of hay averaging 38.62 per cent moisture (minimum, 33.60 per cent; maximum, 48.34 per cent) were placed in the unventilated compartment, and 26,225 pounds of hay averaging 36.82 per cent moisture (minimum, 27.57 per cent; maximum, 46.33 per cent) were placed in the ventilated compartment. The height of the hay in the unventilated compartment was 14¼ ft; that of the ventilated compartment was 15 ft.

The following zones were established in each compartment: No. 1 at the 4-ft level; No. 2 at the 7-ft level; No. 3 at the 11-ft level; and No. 4 at the 13-ft level. Thirty-six thermocouples were placed at comparable locations in these zones, eighteen in each compartment.

Four vertical holes, 3 in in diameter, were cut to a depth of approximately 18 in in the surface of the hay, two in each compartment. In the unventilated mow, hole No. 1 was 7 ft from the front or open side of the mow and 6 ft from the center partition; hole No. 2 was 16 ft from the open side of the mow and 6 ft from the center partition. In the ventilated mow, hole No. 3 was 7 ft from the front or open side of the mow and 6 ft from

[3] "Oxidation and Gas Formation in the Spontaneous Heating of Hay." E. J. Hoffman. Journal of Agricultural Research, vol. 51, no. 6: 527-546. 1935.

the center partition; hole No. 4 was 16 ft from the open side and 6 ft from the center partition. The frustum of a metal cone, the larger base of which was fitted on the inside with a wooden collar to hold a low-speed anemometer, was inserted in each hole. When in position the anemometer was level with the surface of the mow. Although it was recognized that such an arrangement could not be relied upon for accurately measuring low velocities, it nevertheless was satisfactory for obtaining data on the relative upward velocity of air near the surface of the mow in the two compartments, induced by the production of heat within the stored hay.

Comparison of the zone temperatures in the two mows is given in Table 1.

TABLE 1. MAXIMUM TEMPERATURE

Zone No.	Unventilated mow		Ventilated mow	
	Temp.	Date	Temp.	Date
1	59.0 C	June 11, 18	56.5 C	June 9, 12
2	63.5 C	June 12, 13	59.5 C	June 12
3	62.5 C	June 12, 13	63.0 C	June 11
4	63.5 C	June 11	49.0 C	June 13

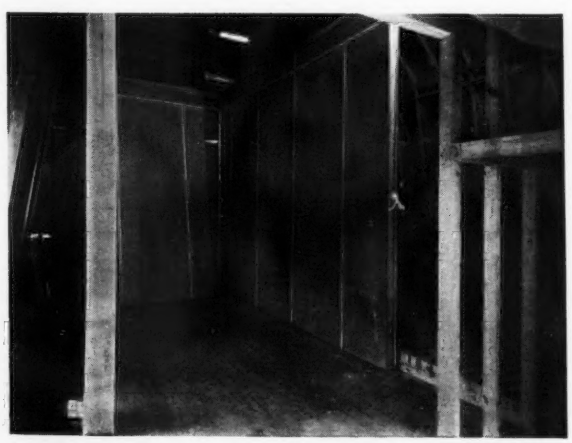
MAXIMUM AVERAGE TEMPERATURES

Zone No.	Unventilated mow		Ventilated mow	
	Temp.	Date	Temp.	Date
All Zones	58.0 C	June 11	55.0 C	June 11
1	56.6 C	June 11	53.5 C	June 9
2	56.7 C	June 12	54.9 C	June 12
3	61.0 C	June 11	61.9 C	June 11
4	63.5 C	June 11	49.0 C	July 13

Out of a total of 38 sets of readings for 38 days the average temperature in Zone 1 was greater in the unventilated mow than in the ventilated mow in 38 instances. The greatest difference was 8.7 C on July 6.

For the same number of readings the average temperature in Zone 2 was greater in the unventilated mow than in the ventilated mow in 36 cases. The greatest difference was 8.4 C on July 26.

Out of a total of 38 readings the average temperature in Zone 3 was greater in the unventilated mow than in the ventilated mow in 17 cases (the average was the same in one instance). The greatest difference was 4.5 C on July 26, although on June 5 it was 3.7 C. In the 20 cases in which the average temperature was greater in the ventilated mow than in the unventilated mow, the greatest difference was 2.9 C on July 3, although on June 6 and 7 it was 2.1 C, and on June 27 it was 2.2 C.



SHOWING CONSTRUCTION OF STORAGE COMPARTMENT

Out of a total of 36 readings the temperature in Zone 4 (in which there were but two thermocouples—one in each mow) was greater in the unventilated mow than in the ventilated mow in 36 instances. The two greatest differences were 29.0 C on June 12, and 26.0 C on June 23.

Measurement of air velocities near the surface of the hay at the four locations previously mentioned, two in each mow, was made 39 times on 34 days between June 8 and July 27. On the unventilated side, readings were obtained on only 7 days at location No. 1. Here the average velocity was 17.6 fpm; the maximum velocity was 30 fpm and the minimum was 3.5 fpm. Readings were obtained on 21 days at location No. 2. Here the average velocity was 19.2 fpm; the maximum velocity was 31 fpm and the minimum was 7 fpm. On the ventilated side, readings were obtained on 27 days at location No. 3 (comparable to location No. 1 on the unventilated side). The average velocity was 28.6 fpm; the maximum velocity was 48 fpm and the minimum was 13 fpm. Readings were obtained on 23 days at location No. 4 (comparable to location No. 2 on the unventilated side). The average velocity was 21.1 fpm; the maximum velocity was 42 fpm and the minimum was 5 fpm.

Comparison of these data for the two mows not only shows greater average and maximum air velocities, but also measurable velocities over a greater number of days in the ventilated mow than in the unventilated mow. Of significance also is the fact that, on the unventilated side, measurable velocities did not occur until July 6 at location No. 1 and until June 29 at location No. 2, while on the ventilated side measurable velocities occurred on the first day readings were taken—June 8. These velocities ceased on July 17 on the unventilated side, and on July 15 at location No. 3 and on July 20 at location No. 4 on the ventilated side.

During the course of this experiment 16 gas samples, 8 from each mow, were collected at a point 6 ft from the floor, 8 ft from the open or alley side of the mow, and 5 ft from the central partition. Analyses of these samples, made by Dr. E. J. Hoffman, are given in Table 2.

TABLE 2. ANALYSIS OF GAS SAMPLES

No.	Date	Mow	CO_2	O_2
1	June	Unventilated	5.90	14.78
2	10	Ventilated	2.95	17.81
3	June	Unventilated	4.28	16.51
4	15	Ventilated	2.53	18.18
5	June	Unventilated	3.02	18.94
6	22	Ventilated	2.85	19.71
7	June	Unventilated	3.43	17.47
8	27	Ventilated	2.69	18.02
9	July	Unventilated	2.71	18.13
10	6	Ventilated	2.11	18.94
11	July	Unventilated	2.05	18.97
12	13	Ventilated	1.60	19.43
13	July	Unventilated	2.24	18.63
14	20	Ventilated	1.43	19.39
15	July	Unventilated	2.10	18.45
16	27	Ventilated	1.62	19.39

Attention is called to the consistently higher oxygen content and the lower carbon dioxide content of all the samples collected from the ventilated mow, which definitely indicates a greater dilution of the gases in the ventilated mow than in the unventilated mow.

All the hay was removed from the two mows on July 28 and 29 after it had been in storage for practically 8 weeks. At this time the height of hay in the unventilated mow was 9⅔ ft and that of the ventilated mow was 9½ ft.

Continuous observation was made of the hay at corresponding levels as it was forked from the two mows. Judged in this manner there was more moldy hay and brown hay in the unventilated mow than in the ventilated mow. With the exception of the hay on the top to a depth of about 1 ft, which was very moldy in both mows, the mold deposits were heavier in the unventilated mow than in the ventilated mow. The contrast in color and mold formation was very marked in the hay occupying approximately the lower 5-ft portion of the two mows. Furthermore, in this region the hay in the unventilated mow felt decidedly damper than did the hay in the ventilated mow.

WATER LOSSES SHOW LITTLE VARIATION

There was practically no difference in the total loss of water in the hay in the two mows during the period of storage as determined from samples of hay collected from each load as removed. The final average moisture content of the hay in the unventilated mow was 15.26 per cent, representing a loss of 23.36 per cent. That of the hay in the ventilated mow was 13.54 per cent, representing a loss of 23.28 per cent.

However, the loss of water was materially greater in the hay occupying the lower portion of the ventilated mow than in the hay in the lower part of the unventilated mow. The average moisture content of the last four loads of hay taken from the unventilated mow, weighing 8,330 lb and comprising 44.49 per cent of all the hay in this mow, was 16.61 per cent, a loss of 22.01 per cent, while that of the last four loads taken from the ventilated mow, weighing 8,470 lb and comprising 49.59 per cent of all the hay in this mow, was 12.66 per cent, a loss of 24.16 per cent.

Judged by the temperatures recorded, the air velocities, the moisture losses, the gas analysis, and the quality of the hay, this experiment indicates that the use of an open-work support in the storage of long hay in mows of moderate size is desirable. The desirability, however, of using such a false floor in mows of great height might be questioned on account of the possible effect of increased but nevertheless inadequate aeration due to dense packing of the hay mass. Although the false floor used in these experiments was satisfactory for the purpose intended, the design could be simplified so as to increase its practicability.

Salting Hay. The efficacy of salt as a preventive or retardant of spontaneous heating was studied in one experiment. The mow was divided into two compartments of equal size, separated by a partition of two-by-fours, covered on each side with insulating board, 7/8 in thick. The three other walls of each compartment also were covered with this insulating board. The false floor, previously described, was used in both compartments. Approximately 12¼ tons of first-cutting, long alfalfa hay of good quality was placed in each compartment. This hay averaged practically 35 per cent moisture, the minimum being 27.77 per cent and the maximum 39.27 per cent. Slightly less than 1½ per cent by weight of fine salt was scattered on the hay as it was mowed away in one compartment, no salt being added to the hay in the other compartment. In all other respects storage conditions were practically identical in both compartments. The two mows were built up jointly, hay from each load being divided as equally as possible between the two compartments. The final height of the hay in each mow was 16 ft. Three corresponding zones were established in each compartment: Zone No. 1, 5 ft from the floor; Zone No. 2, 9½ ft from the floor; and Zone No. 3, 12½ ft from the floor. Eighteen thermocouples were placed in each compartment, six in each zone. The 18 thermocouples in the one compartment were located at positions corresponding to those of the 18 thermocouples in the other compartment.

The highest temperature in the unsalted hay, 56½ C, was recorded seven days after filling operations were completed, while that in the salted hay, 57½ C, was recorded at two locations, the first five days and the second seven days after the compartment was filled. After these maximum temperatures had been reached the temperature curve for both the unsalted and the salted mow was gradually downward, broken by but two or three slight and temporary rises.

An interesting fact is that the daily average temperature by zones was higher in the salted hay than in the unsalted hay on all but ten of the 57 days when readings were taken. The greatest difference on the 47 days when the average temperature was higher in the salted than in the unsalted hay was 9.7 C, in Zone 1, 14 days after the hay had been stored.

In Zone 1, out of a total of 57 days the average temperature in the salted hay was higher than in the unsalted hay on 52 days, it being the same in both compartments on one day; in Zone 2, out of 55 days the average temperature in the salted hay was higher than in the unsalted hay on 53 days; in Zone 3, out of 54 days the average temperature in the salted hay was higher than in the unsalted hay on 49 days.

SALTING PRODUCES LITTLE EFFECT ON HEATING OR QUALITY

Equilibrium between the mow temperatures and the outside temperature having been reached after a period of 18 weeks, the hay was removed from the barn. Continuous observation of the hay as it was taken from corresponding levels in the two compartments showed that there was no material difference between the salted and the unsalted hay with respect to color and mold development. All the hay appeared to be well dried out, quite dusty in the upper portion of the compartments, and of a light brown color with the exception of the hay within several feet of the floor and near the walls, which was green in color. There were but few mold spots; for the most part the mold was evenly distributed, with no heavy deposits. All the hay was suitable for feeding.

The salted hay apparently held moisture to a slightly greater degree during the course of the experiment than did the unsalted hay. On the basis of samples of loads in and out, the average moisture content of the salted hay when placed in the barn was 34.84 per cent, when taken out it was 12.95 per cent; unsalted hay in, 34.84 per cent, out 11.19 per cent.

In this experiment the use of 1½ per cent by weight of salt added to 12½ tons of long alfalfa hay averaging 35 per cent moisture had no appreciable effect in preventing or retarding spontaneous heating.

Although salt in liberal quantities may retard fermentation[4], there is no experimental evidence in the Bureau's possession that the addition of salt to hay as it is stored, at least in amounts safe for feeding, will prevent spontaneous ignition. In fact, we have reports of a number of authentic cases of spontaneous ignition where salt had been added to the hay when stored. Although further experimentation is needed to definitely settle this question, the conclusion appears justified *(Continued on page 554)*

[4] "The Effect of Salt on the Microbial Heating of Alfalfa Hay." L. S. Stuart and Lawrence H. James, Journal of Agricultural Research, vol. 42, no. 10: 657-664. 1931.

Farm Refrigerated Storages

By Earl L. Arnold

STORAGE of fruit and vegetables on the farm is becoming an increasingly important problem. Until recent years practically all farm storage was done in cellars of one type or another. As production increased and markets spread over wider areas, and the marketing season became longer, large buildings were constructed as storages. As a general rule, produce did not keep as well in these storages as it had in the cellars.

Experimentation and experience have indicated that the keeping quality of most produce is dependent on four factors, namely proper ventilation, proper humidity, proper temperature, and storage at the proper time in a disease-free condition.

It is not our job as engineers to specify what conditions of ventilation, moisture, and temperature are optimum for any particular product, but as soon as horticulturists specify these conditions, it is an engineering problem to design, construct, and operate structures that will maintain the desired conditions. Also, it is the duty of engineers to assist horticulturists with the engineering phases of the determination of these optimum conditions.

Usually small storage rooms have not presented sufficiently complicated ventilation problems to be worth special study, but the use of larger storage rooms and the tightly closed rooms of refrigerated storages have made it advisable to pay particular attention to this question.

As long as earth floors are used in storages, a humidity sufficiently high for most produce will usually be automatically maintained, but any tight flooring shuts off this source of moisture and makes deliberate control necessary for most kinds of fruits and vegetables.

Until the introduction of modern refrigerating machinery, the control of temperature was the most unsatisfactory of the required storage conditions. The use of mechanical refrigeration allows temperature control to be definite. On this subject we now await the decision of the horticulturists as to what is the most desirable temperature for each particular kind and variety of produce.

Unfortunately the control of temperature has so engrossed the attention of some of us that many farmers have built and are building refrigerated storages, under our direction as engineers, with absolutely no consideration of ventilation or humidity control.

The data on which the following conclusions are based were obtained by personal visits to nearly three hundred farmers and their storages in the North Atlantic states and Ontario. Suggestions and criticisms were obtained in personal interviews with engineers from companies manufacturing refrigerating equipment, and from engineers and horticultural specialists of experiment stations. A large proportion of the storages visited were refrigerated apple storages. Due to limitations in time the remarks that follow will be confined to refrigerated storages on the farm.

STRUCTURES FOR REFRIGERATED STORAGES

The most economical shape of a storage room from the point of view of economical use of insulation, space and machinery is a cube. Since it is not practical to build a storage room of appreciable size to the height this would require, it is desirable that the room approach a square with a ceiling as high as can be loaded conveniently.

It may be desirable to build a room with a very high ceiling, placing a slat floor so that for loading purposes it would amount to two rooms, but which may be refrigerated as a single room.

Unless produce is to be stored at different temperatures simultaneously, it is most economical to make the storage space a single refrigerated room. This uses a minimum of insulation and machinery and will result in most efficient operation of the machinery.

Operators of storages of more than one room quite frequently say that if they were rebuilding they would have only one room. Usually multiroomed storages are built with the idea of selling all of the produce from one room first, then shutting off the refrigeration to this room and saving the operating cost. As the storage is used the owner discovers that it is most convenient to load all rooms simultaneously and thus he does not confine one

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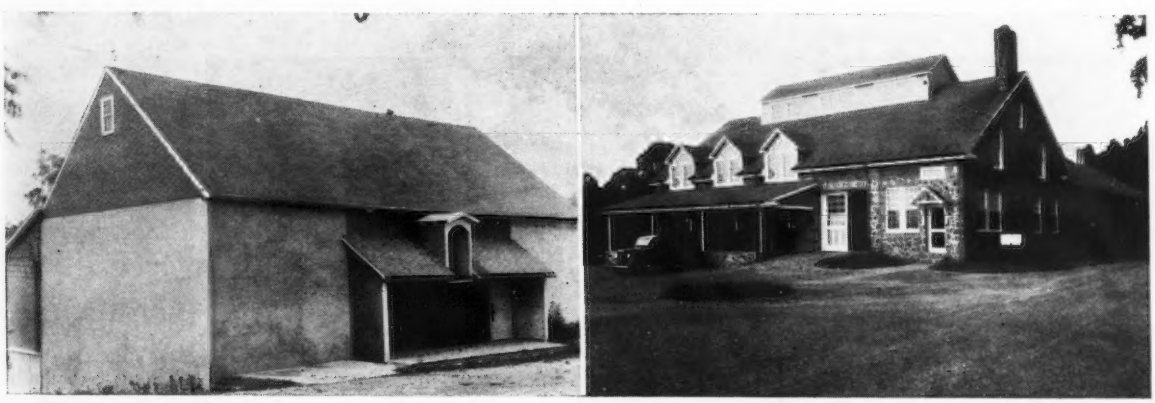


(LEFT) A BARN REMODELED TO MAKE A REFRIGERATED STORAGE. (RIGHT) AN ATTRACTIVE BUT ELABORATE BUILDING BUILT ESPECIALLY FOR REFRIGERATED APPLE STORAGE

variety to a single room. The additional labor cost of operating more than one room is appreciable.

The very slight reduction in cost resulting from operating the machinery at less than full capacity when all the rooms are not being refrigerated is usually less than the interest on the larger investment in constructing and machining several rooms and the additional labor cost in managing the separate rooms.

If the packing room is adjacent to the storage room, produce may be moved from one to the other on roller conveyors with a minimum amount of time and labor. Space adjacent to the storage should be provided for the storage of empty crates, boxes, barrels, etc. It is often convenient to provide this space above the refrigerated room. If a sales room is built in conjunction with the storage, it is desirable that the structure as a whole be attractive in appearance.

The location of the storage should usually be determined by marketing practices. Accessibility to railways and highways may be of primary importance. Other important considerations should be the nearness to the orchards, the topography of the locality, the availability of power, and the availability of an adequate water supply. A storage built on a hillside, similar to a bank barn, may have loading ports on two levels making it possible to load an upper and a lower room without the use of an elevator.

REFRIGERATING MACHINERY

The refrigerating machinery in a storage can be most conveniently operated by electricity. It is the only power with which it is now practical to provide completely automatic operation. If electricity cannot be obtained economically, storage machinery may be satisfactorily operated by gasoline or diesel engines or by water power.

The capacity of the machinery should depend primarily on the amount of produce brought into the storage in 24 hr, the temperature at which it is brought in, the temperature to which it is to be cooled, and the length of time in which this cooling is to take place. A given compressor will cool a considerably larger quantity of produce if a week is allowed for the cooling process, than it will if the produce is to be cooled within 24 hr.

Since the largest refrigeration load is in reducing the temperature of the produce to the storage temperature, the machinery must have a capacity considerably in excess of that needed throughout the rest of the storage period. Therefore, many storages which require 10 to 15 hp for a few days in the autumn can be satisfactorily operated throughout the rest of the storage season with only 5 to 7½ hp.

In situations where electric motors larger than 5 to 7½ hp cannot be used, or where this heavy load on the electric line for a short period of time is to be avoided, it may be desirable to place the compressor in a location such that it can be driven by a tractor. During the period of heavy load it can then be driven by a tractor, and after the storage room has been brought to the desired temperature, a small electric motor, controlled by a thermostat within the storage room, can be used. It is our job as engineers to see that machinery subject to this simple change is available.

The refrigerants most commonly used in farm fruit and vegetable storages are ammonia, methyl chloride, and dichlorodifluoromethane. The latter is commonly known as Freon, Kinetic 12, and F-12. All of them are quite satisfactory. Ammonia requires the use of steel pipe. Copper pipe is used with methyl chloride and Freon. Slightly more refrigeration can be obtained per unit of power with ammonia than with either methyl chloride or Freon.

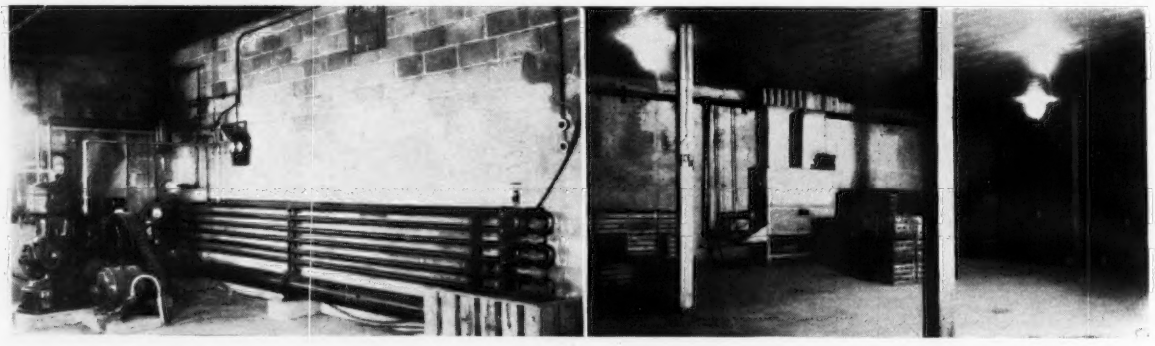
The use of ammonia may result in longer life of the machinery. Methyl chloride and Freon both have a tendency to remove scale and corrosion from metal parts with which they come in contact. Some of this material will eventually be carried by the refrigerant into the compressor where it will contaminate the lubricating oil.

Freon has been widely advertised as the perfect refrigerant. It is non-inflammable, non-corrosive, and normally is not highly toxic. However, in the presence of an open flame it breaks up into other chemicals, one of which is phosgene, the deadly war gas.

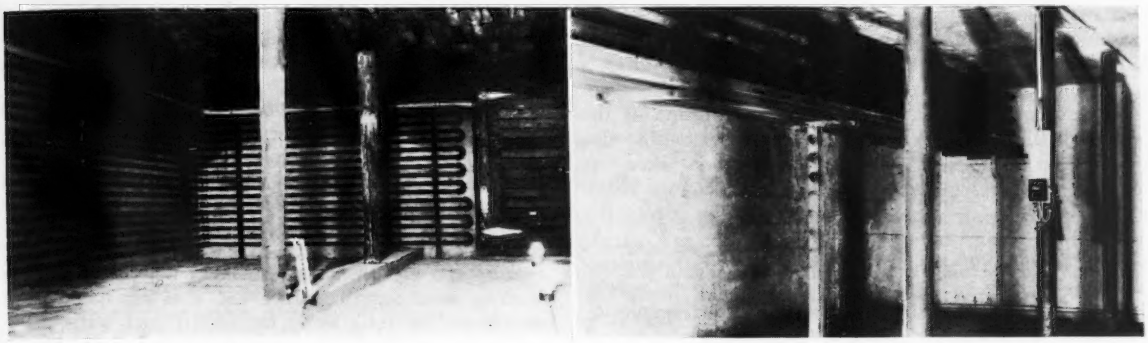
In most cases the pipes within which the refrigerant is allowed to vaporize are located within the storage room. In general there are two arrangements of these pipes. These will be referred to as coil systems and blower systems.

In coil systems the coils of cooling pipes are distributed along the walls or ceiling of the storage room or along both the walls and ceiling.

Since the temperature difference between the warm and cold air in the room may not be more than two or three degrees Fahrenheit, the air circulation with this type of refrigeration is relatively slow. This sluggish circulation becomes increasingly slower as it is forced through larger and more closely piled stacks of produce. It is desirable when using this type of refrigeration to provide space of at least 4 in between the floor and the stored produce, for air circulation. The stacks of produce should have frequent spaces between containers through which the air may rise. Cooling within the closely packed stacks will



(LEFT) COMPRESSOR, MOTOR, AND CONDENSING COILS FOR A REFRIGERATED STORAGE. (RIGHT) A REFRIGERATED STORAGE ROOM WITH A BLOWER SYSTEM, A PART OF THE APPARATUS BEING SHOWN ALONG THE WALL IN THE BACKGROUND



(LEFT) A REFRIGERATED STORAGE ROOM WITH WALL COILS. (RIGHT) CEILING COILS FOR REFRIGERATION

then take place largely by slow secondary air movements induced by the primary flow. The movement of these secondary air currents will be greatly facilitated by the use of containers relatively open on all sides.

A large percentage of the operators using this type of refrigeration install fans to accelerate the air movement. Because of the relatively slow air movement with coil systems the relative humidity of the air in the open spaces of the storage may be a very inaccurate indication of the relative humidity of the air in contact with the produce. Storages of this type are often operated quite successfully with little or no attention being paid to humidity conditions in the room.

This relatively slow air movement undoubtedly results in a slow removal of the gaseous products of respiration from contact with the produce. Operators of apple storages using coil refrigeration more frequently report difficulties with apple scald than do operators using blowers.

Good refrigeration can be expected from coils for horizontal distances not exceeding 20 ft from the pipes. Thus, a room 40 ft wide is the largest that can be satisfactorily refrigerated with coils on the walls only. In wider rooms it is necessary to provide cooling pipes away from the walls, preferably near the ceiling, so that no part of the room will be a horizontal distance of more than 20 ft from cooling pipes.

It is desirable to place drip pans under the cooling pipes. If the cooling pipes are located along the ceiling, single drip pans under each vertical tier of pipes will interfere less with the air circulation than will a single wide drip pan under each bunker of pipes.

Various operators of apple storages have observed that apples stored near the ceiling directly under wide horizontal drip pans ripen more rapidly than do apples stored in other parts of the room. They have also observed that apples stored near the ceiling but under the edges of these wide drip pans may be frozen while apples in other parts of the storage room are uninjured.

Since the ice which forms on the cooling pipes is moisture taken from the air of the room, the defrosting water should be retained within the room to assist in maintaining a satisfactory humidity.

A storage refrigerated with the coil system can be ventilated either by fans installed in ducts leading to the outside air or by flues and ducts to the outside air. If ventilating flues are used, the same principles of air circulation apply that apply in the ventilation of other farm buildings, except that throughout much of the season the air within the storage room will be colder than outside air and the flues will serve as intakes rather than outlets.

In blower systems the coils of cooling pipe are contained in compact cabinets and air is forced over them by fans. Blowers are of two types. One is a small unit very similar to a hot water heater on an automobile. A motor-driven fan is mounted directly back of a bank of finned coils. When used in large rooms a series of them are usually mounted along one wall near the ceiling.

When blowers of this type are used, inlet flues should be built from the back of the blower to the floor in such a way that the air drawn through the blower will come from near the floor. Unless this is done produce stored near the blower is likely to cause the air coming from the blower to be deflected back through the blower again without going through the produce.

The use of the small blowers in large rooms results in duplication of complicated machinery.

The other type of blower is larger, and can be obtained in a sufficient variety of sizes so that a single unit will meet the requirements of a single room. This type of blower is placed on the floor usually at one side or end of the storage room. It draws air from near the floor, passes it over cooling coils, and expells it along the ceiling.

Blowers are usually installed with sufficient capacity to handle a volume of air equal to the volume of the room in about 3 min. This insures a rather rapid air movement. If outlet flues from the blower are properly constructed and the vanes in the openings properly adjusted, a uniform distribution of air throughout the room is possible.

It is usually desirable with this type of refrigeration to store produce in comparatively open containers in relatively solid stacks. Aisles or alleys through which air can return to the blower should be avoided. The produce should be stacked with the idea of forcing the air through the stacks.

The rapid movement of air will insure relatively uniform humidity throughout the room. Some operators of apple storages report that with this system they maintain relative humidities of 95 to 97 per cent, with no mold forming unless the fans stop.

Since the accumulation of moisture in the air in any part of the room is prevented, low humidities will result in rather rapid shriveling of the produce. Some operators wet the floor of the storage room frequently. Others ventilate the room when the outdoor humidity is such as to add moisture to the storage room. Blowers equipped with a brine spray to prevent frosting of the cooling coils will maintain high humidity conditions within the room.

Quick removal of the gaseous products of respiration from contact with the produce is brought about by the rapid air circulation.

If the blower is properly connected to outside air ducts

the air within the storage room can be completely changed within a few minutes. Many operators find it desirable to adjust the dampers in these outside ducts so that there is a continual slow change of the air within the room. Dampers so arranged that any desired proportion of the air handled by the blower can be drawn from outside also provide an economical means of refrigeration when the outside air is colder than the air within the storage room.

In most cases it will be found desirable to defrost the blower once a day during the storage season, and oftener during loading. If the storage room is held at temperatures higher than 38 F (Fahrenheit), defrosting can usually be satisfactorily accomplished by stopping the compressor and allowing the blower to circulate the air of the storage room over the coils. For temperatures lower than 38 F this method is usually unsatisfactory.

Blowers are on the market which provide a continual spray of brine over the cooling coils. They do not collect frost, but the brine spray greatly accelerates corrosion so that these machines are quite short-lived.

Blowers not using a brine spray should be installed so that they can be defrosted with the hot refrigerant. If more than one blower is being used, one may be defrosted while another is operating with no loss of power. If only one blower is in use, it is necessary to allow the condensation to take place in it and the evaporation to take place in the condensor. This method of defrosting results in the waste of a small amount of power, but the defrosting can be accomplished so quickly that the loss is slight.

During the loading period the temperatures of the storage room are usually sufficiently above freezing so that defrosting of the cooling coils can be accomplished by stopping the compressor and allowing the blower fan to continue running. Simple and reliable devices can be obtained which will automatically stop and start the compressor at regular predetermined intervals.

Since the use of a blower allows the produce to be stored in more compact stacks, and it is not necessary to leave space for coils along the ceiling and walls, more produce can be stored in a room refrigerated with a blower than in a room of the same size refrigerated by wall or ceiling coils.

I have yet to hear a farmer express regret at having built his own refrigerated storage. As a typical example, I have in mind a 15,000-bu apple storage that was built in the summer of 1935. The owner expects that by the end of the present season it will have repaid the entire cost of construction, the cost of operation, and a reasonable interest on his investment. He expects in the future to be able to store his own apples with enough profit to himself so that he could afford to build a new storage every three years.

Spontaneous Heating and Ignition of Hay

(Continued from page 550)

at this time that salting of hay cannot be relied upon as a safeguard against spontaneous ignition, and it should not be considered a substitute for sufficient curing of hay in the field.

Discussion by F. W. Duffee

IN THE foregoing paper, Mr. Roethe has given us a report that is of inestimable value, and will enable us to make suggestions and recommendations to farmers everywhere as to how they may handle whole hay in such a way as to minimize, if not eliminate entirely, the danger of spontaneous ignition.

It appears to me that it does not entail any great difficulty or expense for farmers to so store hay in their mows that the ricks or bents are not over 12 or 14 ft wide, with ample provision for the circulation of air between these ricks.

The work at the Wisconsin agricultural experiment station has been almost entirely with the storing of chopped hay, and conclusions which can be drawn at the present time are as follows:

If the length of cut is 1 in or less, that is, if the feed table travels 1 in or less for each cut of the cutter head, the hay must be drier than if it were to be stored whole, in order to have it come out of storage green in color. This applies whether the hay is stored in large mows or in ventilated storage bins similar to corn cribs, the widths being from 3 to 9 ft.

As the length of cut increases from about 1 in up to 2 in, the keeping qualities increase and the heating tendencies decrease, there being a very marked improvemnt in the keeping qualities when moving from the 1-in up to the 2-in cut, with the result that at the present time we are unqualifiedly recommending and urging the use of the 2-in cut if the hay is to be chopped.

When a 2-in cut is used, the limited amount of evidence secured last year tends to indicate that chopped hay can be stored almost as damp as whole hay. Specifically, we had hay containing from 23 to 25 per cent moisture come out of storage in good condition, when stored in ventilated containers 4 to 6 ft wide.

The most important factor apparently is the length of cut, others being the width of the storage unit, height as affecting density, and the nature of the ventilated wall. Tight walls, as well as ventilated walls, were investigated. There was no appreciable difference between ventilated walls where approximately 30 to 40 per cent of the surface of the hay was exposed, and netting lined walls where approximately 100 per cent of the surface of the hay was exposed.

Up to the present time our storage units have been limited to 10 and 12 ft high. We are not prepared to state definitely what will happen with higher storage units, but we do not anticipate any very great modification of these recommendations.

Our experiences in storing hay containing up to 41 per cent moisture tends to indicate that if the storage unit is narrow enough and ventilated on the sides, spontaneous ignition can be greatly minimized, if not entirely eliminated. We believe that with a 2-in cut the upper limit of width should be about 8 or 9 ft. As the length of cut is reduced, undoubtedly the width of the storage unit would have to be reduced also.

Other advantages of the longer cut are that it is less dusty and is easier to remove from storage. The disadvantage is that somewhat more storage space is required. Our limited experience indicates that about 300 cu ft per ton will be required when using a 2-in cut.

Author: Professor of agricultural engineering, University of Wisconsin. Mem. ASAE.

What Agricultural Engineers Are Doing

FROM THE USDA FOREST PRODUCTS LABORATORY

JOHN A. SCHOLTEN, agricultural engineer at the Forest-Products Laboratory, is completing a series of investigations on the load-carrying capacities of modern metal connectors employed in various types of timber joints. Modern connectors are essentially shear keys or dowels, which when used in conjunction with bolts give joints many times stronger than the ordinary nailed or bolted types.

The advantage in strength of such connectors results from the fact that they distribute the load more uniformly across the width of the wood members. As a result, smaller timbers can be used to obtain a given joint strength, or, on the other hand, it is feasible to use large timbers more economically and thus compete with other materials in the design of large structures.

The use of metal connectors has increased enormously in the past few years, and they have been employed in such diverse types of structures as bridges, roof trusses, radio and lookout towers, and smaller framed structures.

* * *

Investigations are being made at the U. S. Forest Products Laboratory to develop simple, practical, and inexpensive methods of treating fence posts and other farm timbers with preservatives to make them decay-resistant. Brush treatments, even with effective preservatives, are of small value because little or no penetration of the preservative results. Good penetration can be obtained in some species by simply soaking lumber or peeled posts for two weeks in a 10 per cent solution of zinc chloride or other water-soluble preservative. Complete sapwood penetration was obtained in freshly cut unpeeled aspen posts by allowing a zinc chloride solution, held in a section of an old automobile inner tube, to penetrate, under the force of gravity, the end grain of the posts. By this treatment posts of non-durable species may be made decay-resistant to give good service like untreated cedar posts of high natural durability.

* * *

The painting of wood is being studied at the Forest Products Laboratory to find ways of making satisfactory results more certain and of reducing the cost of paint maintenance to farmers and home owners. Investigations of the experiences of many hundreds of owners discloses wide variations in the amount of service obtained from good house paints. Very often paints fail in half or less than half the life of which they are known to be capable and fail in objectionable ways that make proper repainting expensive. While numerous causes of unreasonably early failures are being found most of them can be traced back to a lack of understanding of the individual peculiarities of the many kinds of house paints now on the market and the combinations of paints that may be used safely in successive paint jobs. If painters are to be taught how to apply each kind of paint correctly and if home owners are to learn how to select suitable kinds of paint for their programs of maintenance and how to see that the coatings are maintained correctly, it will be necessary to have paints classified for sale in some such way as lumber is now classified by species and grade. The Forest Products Laboratory has proposed a system of classifying paints and is using it to guide its studies of programs of paint maintenance.

Contributions Invited

All public-service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new development in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

FROM ARKANSAS

THE Extension Service of the University of Arkansas, College of Agriculture, with the cooperation of the USDA, has recently published a Plan Service Handbook covering houses and other buildings specially adapted to Arkansas farms. Deane G. Carter compiled the book.

* * *

New personnel recently added to the agricultural engineering department at the University of Arkansas includes Kyle Engler, research agricultural engineer; Keith Hinchcliff, to assist in teaching and farm structures; and E. L. Arnold, extension agricultural engineer. W. C. Hulburt has been handling the department's work in farm power and machinery since February, 1936.

FROM THE USDA BUREAU OF AGRICULTURAL ENGINEERING

THE past summer Harry F. Blaney spent about two months vacation in Europe and the East. His observations of agricultural practices in European countries included sub-irrigation in Holland similar to that practiced in San Luis Valley, Colorado; crops such as alfalfa (or clover), corn, grain, and vegetables planted in 25-ft strips in the same field, and harvested by hand, in Germany, Italy, and France; trees planted in vineyards and used as supports on which to train the vines, several varieties of native trees being used for this purpose, and in some instances fruit trees.

* * *

In preparation for making winter snow cover observations, J. C. Marr, R. A. Work, R. L. Parshall, Carl Rohwer, L. T. Jessup, R. B. Allyn, and George D. Clyde inspected old snow courses and established new ones; interviewed officials of the Geological Survey, Forest Service, Weather Bureau, and many others interested, with regard to cooperation in this project; and supervised the construction and provisioning of shelter cabins. In the Medford, Oregon, area arrangements were made for radio transmission of reports from isolated regions. The new courses, located by Carl Rohwer in the northwestern part of Colorado, in addition to others in the headwaters of the Colorado River, are expected to be useful to the Bureau of Reclamation in the operation of the Boulder Canyon and Colorado-Big Thompson projects.

* * *

Field work on the supplemental irrigation project in South Dakota has been completed by Dean C. Muckel. Several irrigation projects for which government loans had been requested were inspected by Mr. Muckel and for such of these as appeared feasible he prepared tentative plans.

* * *

R. L. Parshall reports that a special vortex tube sand trap, with parabolic axis, cast of concrete, was installed in a channel 8 ft wide, at the Bellvue, Colorado, laboratory. Tests indicate that it is capable of trapping out from 85 to 90 per cent of a measured sample placed in the channel upstream from the tube. Under favorable conditions of flow, cobblestones weighing about 10 lb have been moved the entire length of the tube, apparently with little difficulty. However, this type of vortex tube apparently has no marked advantage over the previously tested straight tube of taper design, and is more difficult to construct. Further study of the device may reveal additional information as to its real merits.

* * *

R. L. Parshall attended the meeting of the Upper Colorado River Basin Committee at Denver, October 8-9, at which a large number of new projects were introduced, relating mostly to supplemental irrigation supplies in Colorado, Wyoming, Utah, and New Mexico. The subject of flood control with special reference to silt and soil erosion was also touched upon. On October 25 Mr. Parshall attended the meeting of the Platte Drainage Basin Committee at North Platte, Nebraska, and introduced two new projects, one dealing with underground water resources and the other with the study of developing a suitable device for measuring flood flows that are heavily laden with debris.

* * *

The unit for determining the force reactions of disk plows is being used in an extensive series of tests on the soil plots of the tillage laboratory at Auburn, Alabama. A preliminary examination of the data obtained shows not only a marked difference in the reaction on the disk caused by the various soils but there is a considerable difference in the direct longitudinal draft for the various speeds. For example, in the Cecil Clay plot an increase in speed from 2.45 mph to 4.08 increased the direct pull by nearly 50 per cent; in the Norfolk Sand plot an increase in speed from 4.9 to 6.03 mph increased the direct pull by 33⅓ per cent. In connection with the above disk observations, soil compaction measurements are being made with the pentrometer de- *(Continued on page 562)*

NEWS

Local Committees Initiate Annual Meeting Plans

PLANS for the Annual Meeting of the ASAE at Asilomar, Pacific Grove, California, in June 1938, developed in preliminary form when local committees conferred at the site for the meeting, October 16. The conference followed the fall meeting of the Pacific Coast Section at the same place.

Walter W. Weir, chairman of the Committee on Local Arrangements, has indicated general satisfaction with the facilities at Asilomar for entertaining the Annual Meeting.

At the conference H. B. Walker, chairman of the Meetings Committee, outlined a skeleton program covering the period from Sunday, June 26, to Friday, July 1. Entertainment is planned for those arriving on Sunday and a Council meeting is also scheduled for that day.

Registration and the College Division meeting are listed for Monday morning, June 27. Formal opening of the meeting and a general session are scheduled for the first half of Tuesday morning, to be followed by simultaneous technical division meetings. The annual business meeting is listed to begin at 4:00 p. m. the same day.

Another short general session, to be followed by technical division meetings is planned for Wednesday morning. Thursday morning is given entirely to technical sessions.

Afternoons are reserved for group meetings and entertainment. The annual dinner is scheduled for Wednesday evening and special entertainment is to be provided during the other evenings. Friday is to be available for post-meeting trips.

Mr. Walker also made a suggestion which met with general approval, to the effect that interested Pacific Coast organizations be invited to provide some specific part of the entertainment or special features, rather than to contribute money toward financing the meeting.

A printed prospectus of the meeting, to be sent out in advance, was discussed and listed for further consideration.

Mr. Weir reported favorably on the financial situation and plan for covering expenses of the meeting. It was agreed that he should call frequent meetings of the subcommittee chairmen to coordinate their work and remove any obstacles to progress.

Addresses Oklahoma Farm Chemurgic Conference

ARNOLD P. Yerkes, president of the American Society of Agricultural Engineers, addressed the first Oklahoma Farm Chemurgic Conference, November 9, on the prospect of better-paying farms through reorganized crop programs that would keep men and equipment on farms profitably employed for more months in the year. He said in part, "Good farmers have always endeavored to work out cropping systems which included several different crops, preferably those which could be handled with the same equipment and which did not conflict too seriously with each other in the matter of labor requirements.

"The soundness of this practice has been recognized for years, not only by practical farmers but by the best authorities on farm management.

"Since the farm chemurgic movement involves the production in this country of a number of crops which are needed by or could be used by our industries, but which are either not being grown in this country or grown on a smaller scale than is desirable, it is plain that this offers an opportunity to many farmers to add new crops which may improve the efficiency of their farming systems.

"Among the various new crops which are being recommended for consideration by American farmers are pyrethrum, perilla, Jerusalem artichokes, and tung trees. Crops now being grown in this country, which may offer possibilities for increased acreages if suitable local processing plants are provided, include soybeans, peanuts, sweet potatoes, and sorghum.

"The manufacturing industries of the United States, large and small, have shown themselves willing to cooperate 100 per cent in the plan to use the products of our farmers to the fullest extent. They realize that the more goods bought from the farmers, the more goods there will be bought by farmers.

"But between the farm and many of our factories there must usually be an intermediate step in the way of soybean elevators or processing plants, starch mills, and paper mills, and it is in this field that there is an opportunity for local business men to render a real service to farmers and manufacturers which will be to their own advantage also.

"Without this help from local sources it is much more difficult for the oil from soybeans to reach our paint factories, for the slash pine wood to reach our printing plants in the form of paper, or for the sweet potato to reach our textile mills in the form of starch.

"Farmers in sections where soybean processing plants, paper mills, and starch mills have been built have demonstrated their willingness to cooperate wholeheartedly by producing the necessary raw materials.

"The farm chemurgic program is not a plan for the betterment of farming alone; it benefits everyone—retailers, middlemen, railroads, manufacturers, and professional men.

"While it was conceived as a means of serving agriculture, we all know that anything which helps agriculture helps all other industries as well."

Georgia State Section Holds Fall Meeting

THE annual fall meeting of the Georgia State Section of the American Society of Agricultural Engineers was held in Dawson Hall on the Agricultural Campus, University of Georgia, November 13, at 7:00 p. m. At this hour a banquet was served to the members and their wives or lady friends.

President Walter N. Danner, Jr. opened the meeting by announcing the names of those engineers who had left Georgia since the spring meeting of the Section. Among those mentioned were—E. M. Dieffenbach, transferred to Logan, Utah; L. C. Prickett, removed to Washington, D. C.; and J. P. Proctor, removed to Texas. The president introduced the following to the assembled group: J. L. Shepherd, a new member of the Society, stationed at Abraham-Baldwin Agricultural College, Tifton, Georgia; Mr. and Mrs. J. T. Woodbury, the latter being a recent addition to the agricultural engineering family at Athens; and R. H. Burnett, of the class of 1935, who is now stationed at Ramseur, North Carolina.

Following the announcements the president introduced W. E. Hudson, the toastmaster for the evening.

Following the banquet a dance was held in the physical education building on the Agricultural Campus. The Section members and their partners were guests. The affair was sponsored by the Agricultural Engineering Club of the University of Georgia.

Southern Section to Meet at Atlanta

FOLLOWING its recent custom the Southern Section of the American Society of Agricultural Engineers will hold its annual meeting in February 1938 in conjunction with the Southern Agricultural Workers Association. Dates are Feb. 2-4. Headquarters will be at the Winecoff Hotel.

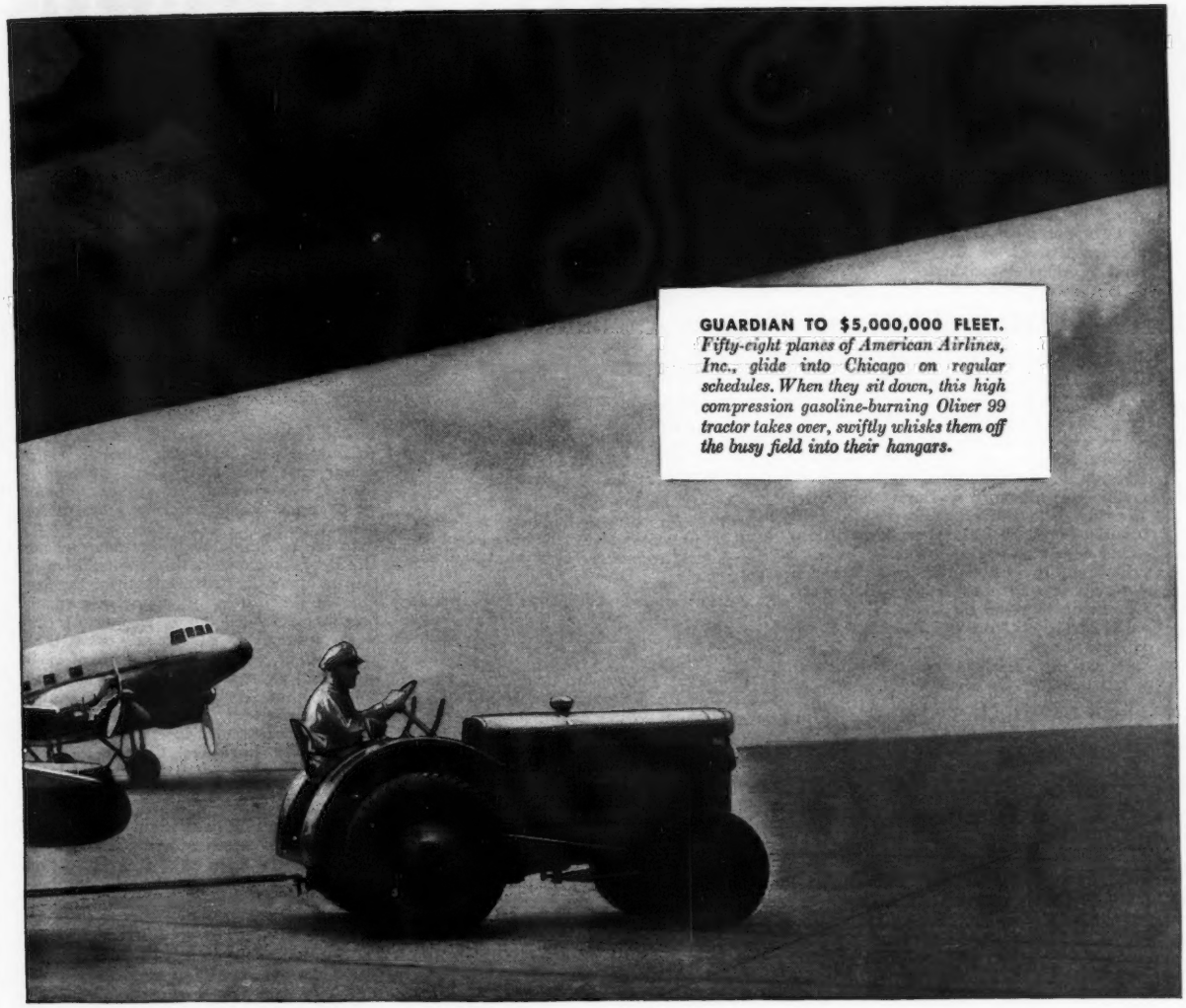
Officers of the Section are D. S. Weaver, chairman, J. T. McAlister, vice-chairman, and O. E. Hughes, secretary. W. N. Danner is chairman of the committee in charge of the meeting.

Arnold P. Yerkes, president of the American Society of Agricultural Engineers, is scheduled as the opening speaker of the first session, the afternoon of February 2. He will talk on "Mechanization of Agriculture." Other features of the opening session will include papers on "The Storage of Grain Sorghum" by F. B. Lanham, and "Developing a Farm Building Plan Service for the Southern States" by S. P. Lyle. Prepared discussion of both papers is planned.

The morning of February 3 will be given to participation in a Symposium on Farm Homes.

Papers listed for presentation and discussion that afternoon include "Methods of Planning, Organizing and Carrying Out A Well-Rounded Extension Program for Terracing Activity" by G. E. Martin; "Progress of Rural Electrification in the South" by P. T. Montfort; "Practical Applications of Electricity on the Farm in the South," by J. P. Schaenzer; and "New Developments in Farm Power and Machinery for the South," by W. E. Meek. A business session will be held at the close of this technical program. *(Continued on page 560)*

THE SWING TO HIGH COMPRESSION



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The same qualities that make a high compression tractor a standout on the landing field make it a standout on the farm. Greater power, easier handling and idling, lower fuel consumption—all help the farmer to get more work done at a lower cost. Most tractor manufacturers now make a high compression, gasoline-burning tractor or offer high compression equipment optionally. They also sell "altitude" pistons or cylinder heads that change over tractors now at work to high compression. And remember, even with a low compression tractor, gasoline can increase power, cut down expensive oil bills and create a smoother-running, easier-handling tractor. Ethyl Gasoline Corp., Chrysler Bldg., New York, N. Y.

MODERN FARMING NEEDS THE ADDED POWER OF

HIGH COMPRESSION

Southern Section to Meet at Atlanta

(Continued from page 556)

Soil and water conservation will be featured in the program for the afternoon of February 4. Subjects and speakers include "An Erosion Control Program Without the Use of Heavy Equipment," by Philomon L. Gully; "The Necessity for Making a Complete Water Disposal Plan in the Establishment of Vegetative Outlets in Advance of Terracing," by John M. Downing; and "Some Basic Formulas of Terrace Design," by John C. Stephens.

Two mornings are left open for attendance at sessions of the Southern Agricultural Workers Association.

New Technical Index Publication

"CURRENT Titles" is a new monthly magazine listing the contents of current publications in the fields of engineering, technology, geology, physics, and chemistry. The world's outstanding English language periodicals are included in this guide to technical reading. Vol. 1, No. 1, October 1937, lists 127 separate publications. AGRICULTURAL ENGINEERING is included.

A subscribers service providing for rapid delivery of periodicals, reprints, or photostats at a small charge is also announced by the publisher.

Annual Meeting Program Announced by Pacific Coast Section

AT DAVIS, California, January 8, the Pacific Coast Section of the ASAE will hold its annual meeting, including its business meeting and election of officers. The meeting will follow a farm machinery conference at Davis on January 7, which will also be of interest to agricultural engineers. Many are expected to attend both meetings.

Opening the meeting with a luncheon at California Inn, the Section will hear an address of welcome by Knowles A. Ryerson, director of Northern Branch, College of Agriculture.

"What the Development of New Techniques Requires Us to Do" is the title of the first paper, to be presented by Walter E. Packard, acting regional chief, land utilization division, Farm Security Administration.

The Section will hear about "Electrical Protection Against Corrosion of Orchard Heater and Orchard Sprinkler Pipe Line Systems" from Gordon N. Scott, pipe line technologist, of Los Angeles.

"Aerial Photographic Mapping as Related to Agricultural Engineering Needs" will be presented by W. L. Cozzens, photogrammetric engineer, Fairchild Aerial Surveys, Inc.

"Citrus Dusting Equipment" is a subject to be presented by Orval C. French, junior agricultural engineer, University of California.

Arnold P. Yerkes, president of the ASAE is to be the principal speaker at a 6:30 dinner winding up the Section meeting.

Roy Bainer is in charge of the Farm Machinery Conference on January 7.

Washington News Letter

from AMERICAN ENGINEERING COUNCIL

ENGINEER-statesmen are advisedly asking what is to be the next step after national planning. Leonard J. Fletcher, who is chairman of the AEC Committee on the Conservation and Utilization of Natural Resources, and a member of the AEC Engineering Economics Committee, has made the following statement which provides substantial food for thought for those who are concerned about national economic planning for the future:

"The next step after national planning is plan enforcement. Plan enforcement and free competition cannot exist together. It is one or the other.

"With a people accustomed to exercising independent thought and action in their business and personal affairs, free competition is a mysterious force that operates without a central guiding hand. It displaces the inefficient; it allows the introduction of new inventions to proceed at just the right pace, not too fast or too slow. It keeps all of the people just a little bit dissatisfied with the things they have so that they are looking for new and better goods and services and, incidentally, the means with which to secure them.

"If the privilege of free competition is curtailed, through the activities of a central planning board, even though its members be prompted by the highest of ideals, one of the most valuable possessions of the people of this country will be destroyed."

Engineers are familiar with planning as an essential to sound engineering and are naturally disposed to look with favor on planning under all circumstances where it does not involve uncharted social and economic considerations.

Planning as an "operational" function of management is accepted by engineers as inherent in the successful administration of public or private enterprise. Planning in the broad sense of determining the "strategies of civilization," and the determination of national policies for present or future generations of citizens, has not yet been considered realistic by most engineers.

* * *

Engineers interested in the social impacts of science and technology will have an unusual opportunity to participate in a series of conferences on this timely subject at the annual meeting of the American Association for the Advancement of Science to be held in Indianapolis, Indiana, the week of December 27, 1937.

Vice-president of the section on engineering, Dean Joseph W. Barker announces that in cooperation with Dr. F. R. Moulton, permanent secretary of the American Association for the Advancement of Science, arrangements have been made for coordinating the stated meeting of the section on engineering, with a series of "Conferences on Science and Society," of which Dr. Harold G. Moulton, president of the Brookings Institution of Washington, is general chairman.

Sponsoring host for the meetings by invitation of the officers of Section M, is the Indiana Engineering Council, representing the organized engineering group of the state of Indiana, including the local sections of the national professional engineering societies. Arrangements for attendance are in charge of a committee of the Indiana Engineering Council.

* * *

"As of September 30, 1937, the ECPD Committee on Engineering Schools, through its delegatory committees had visited 127 institutions of the 133 who had invited visitors for the purpose of accrediting. A total of 617 individual curricula were inspected in the institutions. Civil, electrical, and mechanical engineering curricula provided 119, 116, and 112 separate curricula of the 617 total. The program of the Committee on Engineering Schools in accrediting engineering curricula was partially completed a year ago when announcement was made of the accredited curricula of the schools located in New England and North Atlantic states. Since that time the entire country has been covered and a complete list of 373 curricula in the 127 schools which were visited is being prepared for publication at an early date."

In the meantime, engineers who are not already familiar with this accomplishment may be interested to know that "for the first time in the history of engineering education in the United States, engineering curricula throughout the country have been appraised by a representative body of engineers, and a single accredited list has been published of courses of study deemed worthy of approval. The accrediting process has been carried out during the past two years by the Engineers' Council for Professional Development, a joint organization created by seven national engineering societies for the purpose of enhancing the status of the engineering profession. The participating groups are: American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Chemical Engineers, The Society for the Promotion of Engineering Education, and National Council of State Boards of Engineering Examiners."

"Working through four committees, the Council (ECPD) inaugurated a program dealing with the selection, guidance, training, and recognition of members of the engineering profession. The objective of the Committee on Engineering Schools was to 'formulate criteria for colleges of engineering, which will insure to their graduates a sound educational background for practicing the engineering profession,' and to give recognition to these institutions prepared to teach engineering according to acceptable standards. Accrediting was based on both qualitative and quantitative criteria, and the procedure involved the use of an extensive questionnaire and a personal visit to each institution by a committee of engineers. Participation of the educational institutions was voluntary, and inspection was made only at their invitation."

"The accredited list does not include certain specialized curricula submitted for consideration, which, although apparently outstanding in restricted fields, are not closely related to engineering as interpreted by ECPD. Nor does it include five institutions which have applied for accrediting with the request *(Continued on page 566)*

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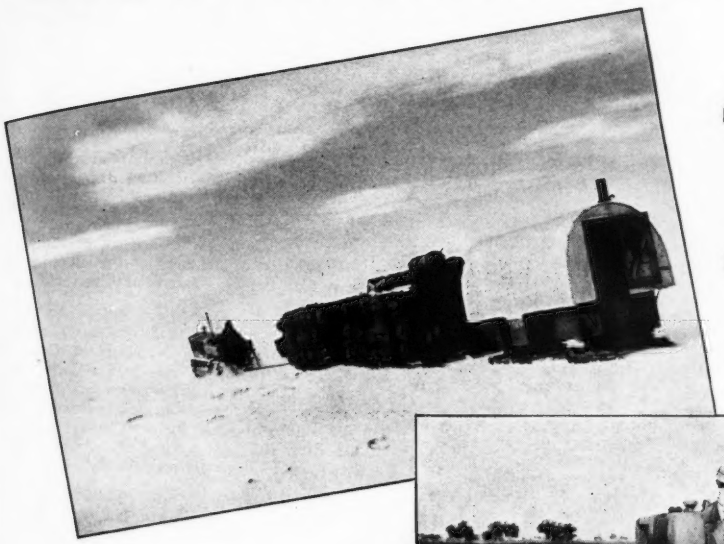

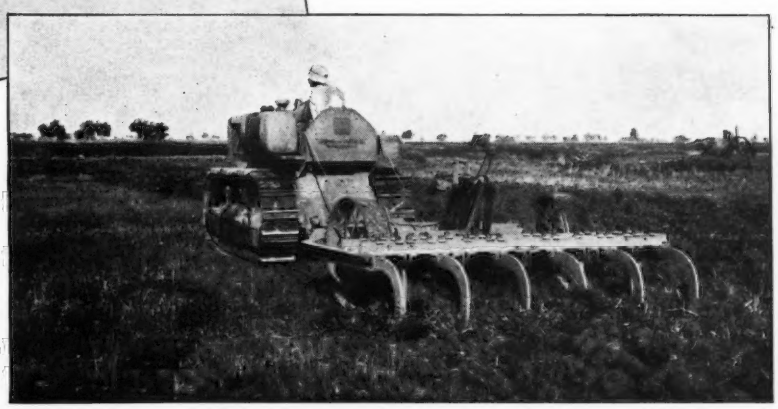

To START a cold Diesel tractor in sub-zero weather requires ample power to overcome the heavy drag of stiff lubricating oil—then power to spin the Diesel against full compression as long as necessary.

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Any territory that has a winter or a summer — or both — has conditions which impose these fundamental requirements on the Diesel tractor's starting system!

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No. 762-A

What Agricultural Engineers Are Doing

(Continued from page 555)

vice used a few years ago for certain field measurements.

* * *

The Colorado Agricultural Experiment Station at Fort Collins has assigned a ten-acre field to E. M. Mervine for experimental work on seedbed preparation and planter trials of sugar beets. He will also run "mechanical thinning" trials on the field.

* * *

G. A. Cumings inspected the cauliflower fertilizer-placement experiment at Mattituck, Long Island, on November 11. There was marked evidence of nitrogen deficiency and inferior growth where less than 2,000 lb of fertilizer per acre was applied. Row applications as compared to broadcasting the fertilizer showed no apparent differences. Such differences must be finally determined by consideration of several factors such as size of plant, earliness of maturity, and the number, size, and quality of the marketable heads.

* * *

A special fertilizer-grain drill which will be used in fertilizer placement experiments with peas, soybeans and possibly with small grains has been practically completed by L. G. Schoenleber, assisted by D. B. Eldredge. The special features include two adjustable sets of furrow openers independently operated, one used for seed and the other for fertilizer; gage wheels on the seed shoes, reversed hopper to place the fertilizer compartment in front; and refined adjustments for the fertilizer and seed dispensing mechanisms.

* * *

S. W. McBirney reports that field tests of the Scott Viner Company sugar beet harvester have been completed for this year. Where conditions were favorable, the machine harvested from 95 to 98 per cent of the beets, topping nearly all of those harvested equally as well as it could be done with hand labor.

* * *

Several sets of the self-aligning disk jointers have been placed in the hands of cooperating farmers for tests in plowing under cornstalks and heavy accumulations of sweet clover and soybean trash left by combines.

* * *

W. M. Hurst and George Stafford report that a white potato digger with certain alterations appears suitable for harvesting sweet potatoes for starch manufacturing purposes at Laurel, Mississippi. However, the successful operation of such equipment requires that most of the potato vines on the ridges be removed and that the rows be "barred off." Attachments for performing these operations are being developed.

* * *

Yield of seed cotton in 1937 on the various tillage plots at Prattville, Alabama, varied from 892 to 1,703 lb per acre. These differences in yield further substantiate the fact that soil structure can be altered by tillage methods and have a direct effect on yield.

* * *

A disk harrow made up of two opposed disk gangs has been altered to permit mounting in the dynamometer unit at the tillage laboratory. The disk harrow when attached to the drawbar of the dynamometer is free to float in a vertical direction. The depth of penetration due to various loadings, angled settings, disk spacings, and disk diameters run at various speeds on the soil plots is recorded on a specially built depth-recording device. The draft required to pull the disk forward is measured and observations are being made on the degree of pulverization effected.

* * *

About 1,000,000 bales of damp seed cotton was dried this season in 500 driers, largely as a result of interest sitmulated by the activities of the cooperative cotton ginning laboratory.

* * *

Apparatus for studying waste heat of cotton gin engines is being installed at the cotton ginning laboratory, Stoneville, Mississippi, to determine the possibilities of using such waste heat in drying cotton.

* * *

The agricultural colleges of the Northeastern States in cooperation with this Bureau and the Extension Service have selected a number of drawings for various types of farm buildings that are especially suitable for conditions in that area. A catalogue illustrating the drawings has been published as USDA Miscellaneous Publication 278, Plans of Farm Buildings for Northeastern States, a copy of which may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 30 cents. A special feature is the reproduction of many of the working drawings which should be of interest to architects, contractors and builders, as well as to agricultural engineers. The plans illustrated in the catalogue may be purchased in the form of blueprints drawn to scale, from the colleges listed in the catalogue.

* * *

A. D. Edgar is making tests on several potato storage houses, located at various points in Michigan, with headquarters at Cadillac. The tests are being conducted in cooperation with Michigan State College.

* * *

An instrument for electrical measuring of the moisture content of corn and small grains is being used experimentally in the corn storage studies in Illinois and Iowa. Preliminary studies and calibration of the apparatus were made in Washington.

* * *

Work of the Missouri CCC drainage camps was inspected early in November by J. C. Wooley, of the University of Missouri, Marion Clark of the Missouri Extension Service and J. G. Sutton and C. E. Jacoby of this Bureau. County agents and drainage district commissioners also took part in the inspection.

* * *

Several camps have constructed ditch inlets in accordance with designs prepared by Mr. Wooley. These consist of thin, reinforced concrete slabs 3 to 6 in thick, laid without forms, on sloping ditch banks formed in the shape of a weir. Some of these structures have been in use more than a year and are in fairly good condition. They need to be carefully made and installed to prevent cracks and escape of water beneath the structure.

* * *

In Marion County, Missouri, there is an interesting demonstration of mole drainage. The drains were put in with a mole plow, costing $160, drawn by a 30-hp tractor. The drains are 60 ft apart and 20 in below the surface. The owner says 40 acres can be gone over in a day with this outfit at a cost of 25 cents an acre. He considers this type of drainage satisfactory and, in gumbo soil, better than tile, since such soil has a tendency to seal tile and prevent the entrance of water.

Personals

F. C. Fenton is joint author with W. B. Balch, of Kansas Agricultural Experiment Station Circular 183 entitled "Hot Beds for Kansas."

Frank P. Hanson was recently promoted to the position of manager of the merchandise bureau of the Caterpillar Tractor Co.

L. F. Livingston, past-president of ASAE, and manager, agricultural extension section, E I du Pont de Nemours & Company, addressed the Pennsylvania Student Branch of the American Society of Agricultural Engineers at State College October 28, on the subject of agricultural explosives. He will address the "All-Agricultural Assembly at Ohio State University on January 11.

E. G. McKibben is joint author with Roman L. Horne of WPA National Research Project Report No. A-2, on "Changes in Farm Power and Equipment, Mechanical Cotton Picker."

H. E. Murdock is author of Montana Agricultural Experiment Station Bulletin No. 344, entitled "A Study of the Operation of Tractors and Implements Under Farm Conditions."

Dr. M. L. Nichols was recently appointed assistant chief of research, Soil Conservation Service, U. S. Department of Agriculture, Washington. More recently he served as a regional engineer of the SCS, and previous to that was for many years head of the agricultural engineering department at the Alabama Polytechnic Institute.

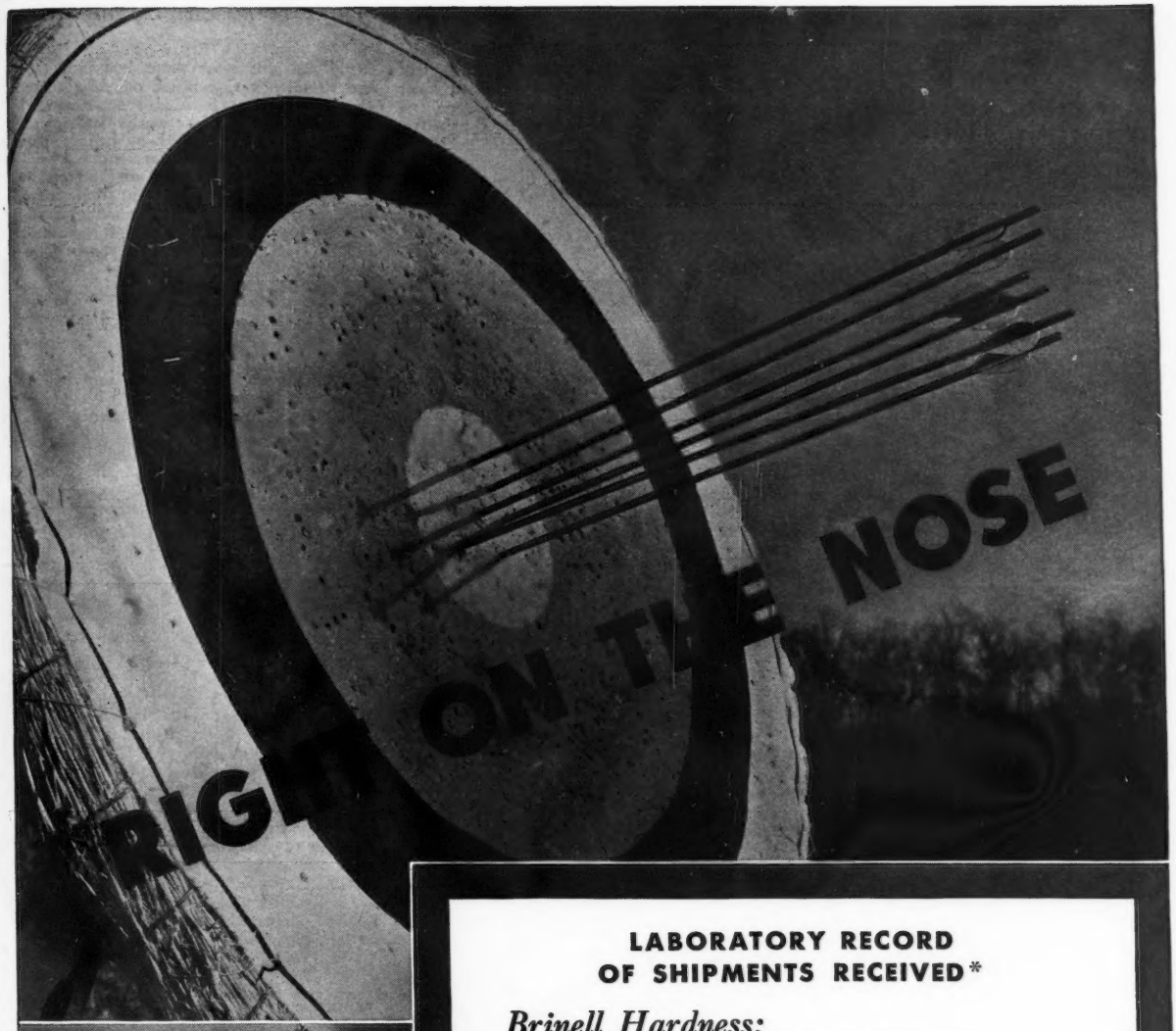
Miss Ellen Pennell, editor, home making department, "The Country Home Magazine," was recently promoted to the position of managing editor of that publication.

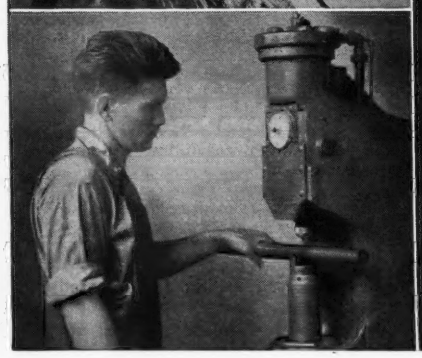
Geo. E. Pickard, engineering department, Massey-Harris Company, Toronto, sailed November 17 for France to assume his new duties as assistant to the chief engineer of the Massey-Harris plants in Germany and France. His new address will be care of Massey-Harris Co., Marquette-lez-Lille, France.

Lee C. Prickett has recently joined the Rural Electrification Administration as agricultural electrical specialist. His post-office address is Branchville, Md. More recently he was rural electrification specialist from the Georgia Agricultural Extension Service.

Harry E. Roethe is the writer of USDA Bureau of Chemistry and Soils Leaflet No. 44, entitled "Fires on Farms."

John B. Woods, until recently connected with the U. S. Soil Conservation Service, has purchased the Jelm Implement Company at Earlyville, Illinois, and renamed it the Earlyville Implement Company. He will merchandise and service McCormick-Deering farm machinery.





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Brinell Hardness:

Shipment	Sample A	Sample B	Sample C	Sample D	Average
1	302	293	269	286	287
2	302	277	277	293	288
3	293	302	293	302	297
4	302	302	286	277	292
5	286	293	286	269	283

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UNITED STATES STEEL

Washington News Letter

(Continued from page 560)

that the visits of inspection be made in 1937-38. Finally, provision is made by ECPD for annual review of the accredited list through its Committee on Engineering Schools, of which Dr. Karl T. Compton, president, Massachusetts Institute of Technology, is chairman. Requests for further information regarding ECPD and the accrediting program may be addressed to A. B. Parsons, secretary, Engineers' Council for Professional Development, 29 W. 39th Street, New York, N. Y."

* * *

In response to an invitation from the Federal Board of Surveys and Maps, the American Engineering Council through its Surveys and Maps Committee has prepared the following statement to be used by a special committee in an effort to have the "mapping agencies" seek additional appropriations from Congress for acceleration of "basic mapping" under the Temple Act during the fiscal year ending June 30, 1939:

"American Engineering Council has for many years vigorously supported, in the public interest, the requests of our member engineering organizations that the basic map of the United States be completed at the earliest possible date. As a move in the right direction, American Engineering Council has accepted, in principle, the recommendations made by Secretary Ickes in response to Senate Resolution 281 which requested a program for expediting the topographic mapping of the United States. The recommendations involve a 20-year program and the expenditure of $100,000,000. They would give the Geological Survey $4,000,000 for topographic surveys and maps, and the Coast and Geodetic Survey $1,000,000 for first and second order control surveys in 1938 under such items as the directors of the surveys may designate.

"The Surveys and Maps Committee of American Engineering Council earnestly hopes that steps will be taken by the Bureau of the Budget and the Congress to appropriate the minimum of five million dollars that is called for in this program. They believe that in the interest of public economy, of present immediate need, and of the future conservation of our national resources, this step should be taken.

"Earlier communications from American Engineering Council to the President, to the committees of the House and Senate and to the various federal and state agencies involved, have pointed out that the fulfillment of the original Temple Act passed in February 1925 and supported unanimously by map makers and map users alike, is long overdue. We can think of no more practical contribution to both national economy in a broad sense of planning and national economy in a strict budgetary sense than can be made by the administration and by the Congress at this time.

"No previous national administration has more consistently proven the value and need of a basic mapping program. The work of the National Resources Committee and of its various subcommittees, the aggressive development of soil conservation, the programs of land control and utilization, the planned approach to the wide use of our natural resources, the control of flood waters—all depend in detail on the basic map as an essential tool. Maps are the very first requirement of the committee, board, or individual who plans or designs public or private works of any kind.

"Not only details for fulfillment of plans for the better utilization of our water resources, of our land and mineral resources, of the state planning of these resources demand adequate basic maps in many localities, but final judgment on many questions of national policy must be based on factual data, the basis for which is found in adequate triangulation and contour maps of the states.

"These principles have been stated over and over again during the last several years by committees of American Engineering Council and of its member engineering societies, including the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Society of Agricultural Engineers, American Institute of Consulting Engineers, Association of Consulting Management Engineers and the Society for the Promotion of Engineering Education, and some forty-four state and local engineering associations which have had intimate contact with the needs of their respective states and communities. In addition, many other scientific and technical agencies have supported the need of an adequate mapping program. These include the National Science Advisory Board, the National Resources Committee, Association of American State Geologists, Society of American Military Engineers, Association of State Highway Officials, and many state planning boards. Several states, including Oregon, New Jersey, Pennsylvania, Texas and Iowa, have introduced legislation emphasizing the need for this basic instrumentality of both private and public utilization of their resources.

"This very considerable body of technical opinion expressed both by map users and map makers, which has accumulated during the past three or four years, is united as to the need. The committee of American Engineering Council believes that the proposal of the Federal Board of Surveys and Maps has the earnest support of all agencies interested. The American Engineering Council would be glad to have the opportunity at the proper time and the proper place to arrange in detail for the expression of expert opinion from these many organizations.

"Further, the Committee, in supporting this first step toward an adequate mapping program, perceives it as only the beginning of a long-desired objective and earnestly hopes that every effort be made to carry out the complete plan with additional appropriations annually of such size as will complete a basic map for the United States at the earliest possible date. The Committee on Surveys and Maps of American Engineering Council wishes to record itself as willing to help forward this program in every proper way consistent with the great public desirability for fulfillment of a very real social and economic need for accurate knowledge of both horizontal locations and topography in all sections of this country."

* * *

Definite recommendations for a federal public works department to be created in the process of government reorganization which is still before Congress, are to have consideration during the 18th annual meeting of the American Engineering Council's Assembly in Washington on January 13, 14 and 15, 1938. Special studies by the staff and a comprehensive report of the AEC Public Works Committee regarding the structure of a public works department are to be ready for discussion at that time.

Engineers have advocated a public works department for many years, and now that the President's Committee on Administrative Management have also recommended the creation of a public works department, engineers are encouraged to believe that the proposal may be due for serious consideration by this next session of Congress. It is not likely to be without opposition, however, because even the Brookings Institution, which made a study for Senator Byrd's Committee, failed to support the idea, although they did recommend many changes in public works and engineering functions.

One of the major problems is to determine what are public works and to name those bureaus or activities among federal government agencies which should be included in the initial structure of a public works department. The President's Committee came to the conclusion that such a department should "advise the President with regard to public works" and that it should be prepared to serve other government agencies as indicated in the following quotation:

"To design, construct, and maintain large-scale public works, which are not incidental to the normal work of other departments, except as their agent on request; to administer federal grants, if any, to state and local governments, or other agencies for construction purposes; and to gather information with regard to public works standard throughout the nation."

The complexity of the problem is indicated by the fact that neither one of the more recent studies undertook to name those engineering or public works agencies or functions which should be drawn together into a U. S. Public Works Department. The President's Committee concluded its suggestion, as follows: "The Committee does not assign to the new department particular agencies and bureaus, but leaves this assignment to the Executive, when, and if, the Congress enacts a law setting up the general departmental structure."

Conditions with reference to "public works" have changed materially in recent years, and engineers in both public and private life have made many observations and acquired a vast amount of actual experience with public works programs. Recognizing that fact, the American Engineering Council is anxious to help to unite engineers in their public responsibility with reference to public works activities undertaken by the federal government, the several states, and local committees. To that end, engineers and engineering organizations are invited to express themselves to the AEC Public Works Committee through the AEC office 744 Jackson Place, Washington, D. C.

As a premise, one nationally known consulting engineer with a vast amount of practical experience in the construction field has suggested that "those activities of a civilian character should be allocated to such a public works department, and those for defense by the Army and Navy should remain as they are." In that connection, it has been said that "in the interest of simplicity, for the association of related activities to effect a reduction in overhead costs, for the elimination of duplication, to provide opportunities for a technical personnel of the highest type, and to facilitate the planning of government financial programs, the federal government should have that concentration of public works activities which has already proven satisfactory in our states and municipalities and in the more progressive foreign countries."

(Continued on page 568)

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Washington News Letter

(Continued from page 566)

The American Engineering Council has appointed a special committee to consider the ramifications of Congressman Randolph's H.R.7939 for the promotion and coordination of scientific research activities as a means for the prevention of unemployment in the future. Mr. Randolph seems to be leading a school of thought which publicly subscribes to the philosophy that an even greater application of technology to industry and business is necessary to insure that expansion of capital outlets which guarantees an increasing volume of employment.

Although the Randolph Bill has not come up for action in Congress and is still subject to change, it has aroused much interest among members of the engineering profession. A number of engineers have already filed criticisms and suggestions, and Mr. Randolph informs us that he is anxious to have reactions representing all fields of technology. Council has not formulated an official policy with reference to this legislation, but the following observations are made available for the convenience of those engineers and engineering organizations who may be concerned about either federal government support or control of research in both pure and applied science:

"In essence, Congressman Randolph proposes that instead of having a variety of research projects carried on by government bureaus and special research agencies seeking government funds in an unplanned way for their particular projects, that these various efforts be coordinated through the establishment of an advisory board made up of representatives of the government, of scientists, and of industry. That approach to the problem has appealed to this organization.

"You may know that last year the land-grant colleges introduced a bill proposing the establishment of engineering experiment stations in each state paralleling in general the agricultural experiment station idea. Since the land-grant act is administered through the Department of Agriculture, the land-grant colleges believe that any development of such experiment stations should be so administered. Meanwhile, the state universities in nineteen states—in some of which there are also land-grant colleges—sought to have this bill modified so that money could be spent at state universities as well as at land-grant colleges in particular states. In this proposal, the administrative machinery would be located in the Bureau of Standards of the U. S. Department of Commerce.

"A third bill confused the issue further by proposing a plan for government expenditures in the field of business research, this one to be headed up in the Department of Commerce. Each of these bills has had the active support in Congress of the particular group of representatives of educational associations, the land-grant colleges having a committee and the state universities another, the business school having a third. Meanwhile, of course, certain government bureaus, like the Bureau of Standards and the Bureau of Mines, seek money for fundamental research and sometimes the regular functions of the government in their research efforts are confused with the proposals outlined above.

"So far it has been impossible to secure a meeting of minds between the college groups. Within certain states there is a feeling of sharp competition and as a result in earlier years none of the bills have succeeded in passing largely because there has been no meeting of minds in the state by which the congressman in that state could be induced to take action.

"It seems that Congressman Randolph is approaching this matter in a way in which some order might be brought out of this chaos. While the American Engineering Council has not committed itself to any detail of the bills, we have been assisting Mr. Randolph in securing all the information he can from all the sources, so he will have before him as complete a picture of the problem as possible before he revises his bill. Our understanding is that Congressman Randolph has the friendly support of the President in his efforts, and this seemed to be an added reason, if anything was to be done in this matter, for working with Congressman Randolph in perfecting his legislation."

Hydrologists to Meet at Davis, California

A JOINT meeting of the National Research Council and the American Geophysical Union, Section of Hydrology, has been scheduled to be held at Davis, California, January 8 and 9, 1938.

A symposium on hydrologic aspects of the forest and range is listed for the opening session.

In the afternoon of the same day forest and range hydrology are to be considered in relation to water supply, forest management, soil conservation, the livestock industry, and flood control.

"The Effect of Dams on the Regimen of the Colorado River," "Geological Evidences of Recent Floods," "Evaporation and Runoff from Snow in the Alpine Zone of our Western Mountains," "Control of Major Floods," and "Recent Studies on Quality of Water for Irrigation" are titles of papers listed for presentation at the second morning session.

A Western Interstate Snow Survey Conference is planned for the closing session, the afternoon of January 8. This part of the program will be under the supervision of the regional committee of the American Geophysical Union, of which Prof. M. P. O'Brien, University of California, is chairman.

ASHVE to Hold 44th Annual Meeting

NEW YORK City will be the site, the week of January 24, 1938, of simultaneous meetings of the American Society of Heating and Ventilating Engineers, the American Society of Refrigerating Engineers, and the National Warm Air Heating and Air Conditioning Association, and of the Fifth International Heating and Ventilating Exposition.

Scheduled papers of possible interest to agricultural engineers include "Air Distribution from Side Wall Outlets," "Relation of Body Changes to Air Changes," "Studies on Bacterial Control in Air Conditioning," "Drop in Skin Temperature and Sense of Coolness with Various Air Conditions," "Control of Air Conditioning in Large, Medium, and Small Buildings," "Physiological Reactions and Sensations of Pleasantness Under Varying Atmospheric Conditions," "Study of Methods of Control and Types of Registers as Affecting Temperature Variations in the Research Residence," "Heat Transfer Through Single and Double Glazed Steel Sash" and "Condensation of Moisture on Insulated Walls."

ASAE Meetings Calendar

January 8—Annual meeting of the Pacific Coast Section, at University of California, Davis.

February 2, 3, and 4—Meeting of the Southern Section (in conjunction with the annual convention of the Southern Agricultural Workers Assn.), Atlanta, Ga.

June 27 to 30—Annual meeting of the Society, Asilomar at Pacific Grove, Calif.

Gully Erosion Report Available

THE reort of the ASAE Subcommittee on Control of Gully Erosion, for 1936-37, is now available in mimeograph form. One copy will be mailed free to any ASAE member on request.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the November issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Richard G. Boardman, trainee, J. I. Case Company, Peoria, Ill. (Mail) 309 Fifth St.

Clarence H. Christopherson, instructor in farm buildings, Division of Agricultural Engineering (and assistant in Experiment Station) University of Minnesota, St. Paul, Minn. (Mail) 2012 Como Ave. W.

Walter C. Hinkle, instructor Farm Machinery Department, New York State School of Agriculture, Alfred University, Alfred, New York. (Mail) 38 S. Main St.

Charles H. Kent, salesman and collector, J. I. Case Co., Kansas City, Missouri. (Mail) 3327 Wyandotte St.

Norman E. Leach, graduate assistant, Agricultural Engineering Department, A. & M. College of Texas, College Station, Tex.

Dwight S. McVicker, associate agricultural engineer, Soil Conservation Service, Department of Agriculture. (Mail) 132 W. Prescott Ave., Salina, Kans.

J. E. Miller, architect, Bureau of Agriculture. (Mail) 8719 Second Ave., Silver Spring, Md.

North H. Newton, engineering aide, Soil Conservation Service, U. S. Department of Agriculture. (Mail) Camp SCS-16-Ky, Mayfield, Ky.

C. E. Peach, instructor, Agricultural Engineering Department, A. & M. College of Texas, College Station, Tex.

TRANSFER OF GRADE

Orval C. French, instructor and junior agricultural engineer, University of California. (Mail) University Farm, Davis, Calif. (Junior to Member.)

Kenneth R. Frost, associate in agricultural engineering, University of California. (Mail) University Farm, Davis, Calif. (Junior to Member.)

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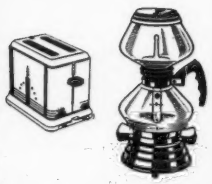

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Be sure you get all the light you pay for . . . by using the new, brighter MAZDA lamps made by General Electric. Improvements within the last twelve months actually make these lamps brighter than ever before and make them *stay brighter longer*. In the 60-watt lamp, for example, a new high-efficiency filament provides 10 per cent more light than the same-sized lamp of a year ago.

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Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

THE EFFECTS OF SERVICE ON AUTOMOBILE CRANKCASE OILS, *J. I. Clower and N. W. Conner.* Va. Engin. Expt. Sta. Bul. 28 (1937), pp. 40, figs. 14. Studies are reported the results of which indicate that all of the changes which an oil in a crankcase undergo are not deleterious. Some of the changes are beneficial rather than harmful. For example, film breakdown and viscosity index tend to improve with use. Other properties, such as carbon residue, neutralization number, ash and iron content, hemacytometer count, and precipitation number show a decided tendency to increase, while viscosity, surface tension, dilution, and pour point follow no definite trend but vary widely with operating conditions.

It appears that the importance of the properties of new oils, as measured by laboratory tests, has been overemphasized, because oils in service only retain their original properties for a comparatively short period of time. Consequently the major problem is not one of selection but rather one of maintaining the oil in the desired condition.

An extensive bibliography is included.

LOW-COST HOUSING. Fed. Housing Admin. Circ. 3, rev. (1936), pp. 30. This covers in general terms the procedure involved in the insurance of mortgages on low-cost housing projects and sets forth the administrative rules and regulations governing such insurance.

LIST OF INSPECTED HOUSEHOLD ELECTRICAL APPLIANCES. Underwriters' Labs. List HEA 736 [1936], pp. 103, pl. 1. This list contains household electrical appliances, small wiring devices, and other similar equipment.

NOTES ON SOIL MECHANICS AND FOUNDATIONS, *F. L. Plummer.* Ann Arbor, Mich.; Edwards Bros., 1936, pp. VII + 139, figs. 129. This publication summarizes available information on soil dynamics as related to foundations. It contains chapters on the geology of soils; soil properties and soil tests; colloids; mechanical analysis; soil moisture and limits of consistency; subgrade soil classification; permeability; shearing strength, cohesion, and internal friction; compressibility and consolidation; frost action in soils; stress distribution in soils; bearing capacity of soils; bearing capacity of piles; settlement of structures; stability of slopes; soil pressure against retaining walls; and soil compaction and proctor tests.

UTILIZATION OF COMBINED HARVESTER-THRESHERS AND COST OF HARVESTING SMALL GRAINS WITH A COMBINE (Northern Great Plains and Pacific Northwest, 1933), *R. S. Washburn.* U. S. Dept. Agr., Bur. Agr. Econ., 1936, pp. [2] + 29, fig. 1. The purpose of this mimeographed report is to show the extent to which combines are used, the size of combines, the kind of grains harvested, and what present owners and prospective purchasers of combined harvester-threshers can reasonably expect in the way of costs of using combines in grain-producing areas of the northern Great Plains and of the Pacific Northwest. The study was made in April, May, and June, 1934, and for the most part applies to the crop year 1933. The field data were obtained by personal interviews with 1,674 farm operators.

The data show that combines in the northern Great Plains were used an average of 152 hr annually, of which 146 were for home work and 6 were for custom work. The work of combines in all areas was principally that of harvesting and threshing wheat. Combines in the Pacific Northwest were used an average of 186 hr annually, of which 172 were for home work and 14 were for custom work. The work of combines in these areas was almost entirely that of harvesting and threshing wheat. Of an average of 515 acres of grain cut per combine per year for combines of all sizes, 474 acres were cut on the home farm, of which 456 acres were wheat.

In the northern Great Plains, 68 per cent of the 12-ft combines cut 400 or fewer acres annually, whereas 61 per cent of the 16-ft combines cut over 400 acres annually. For combines of all sizes, 37 per cent cut 300 or fewer acres, 46 per cent cut from 301 to 700 acres, and 17 per cent cut over 700 acres annually. In the Pacific Northwest, 75 per cent of the 12-ft combines cut 400 or less acres annually, whereas 69 per cent of the 16-ft machines cut over 400 acres annually. For all combines represented, 29 per cent cut 300 or fewer acres, 54 per cent cut from 301 to 800 acres, and only 17 per cent cut over 800 acres annually.

For the northern Great Plains, fuel and lubricants constituted 15.1 per cent; cash repairs, 15.9; owner and family labor on repairs, 2.0; hired labor, 0.4; depreciation, 51.6; and interest, 15.0 per cent of the total annual cost of operating combines. For the Pacific Northwest, the percentage distribution of the total cost was as follows: Fuel and lubricants, 14.3 per cent; cash repairs, 24.0; owner and family labor, 2.9; hired labor, 1.2; depreciation, 41.4; and interest, 16.2 per cent.

ELECTRIC MOTORS FOR FARM MACHINERY, *F. E. Rowland.* [Rothamsted Expt. Sta., Harpenden], Rothamsted Confs. No. 21 (1936), pp. 42-53, figs. 14. Technical information on motor adaptations to farm machinery is presented.

FARM MACHINERY AND EQUIPMENT, *H. P. Smith.* New York and London: McGraw-Hill Book Co., 1937, 2. ed., pp. XIII+460, figs. 700. This is the second edition of this book, in which the greater portion of the text has been revised and rewritten to take full account of the many developments in farm machinery during the past 7 yr, particularly in tractor-drawn implements. New chapters have been added, discussing farm machinery in its relation to agriculture, dusting and spraying equipment, and terracing machinery. The chapters on wagons and motor trucks have been combined and supplemented with a treatment of the automobile trailer. Many of the illustrations have been replaced, by either new or improved ones, to show the latest types of machines now available.

The discussion of the developments on the mechanical harvesting of cotton has been brought up to date, giving results of experimental work done during the past few years, especially at the Texas Experiment Station. Improvements in haying machinery, such as placing the gears in a bath of oil enclosed in a dustproof case and the window pick-up baler, are described and illustrated. A number of illustrations show machinery equipped with rubber tires, an innovation on many farm implements. In general, an effort has been made to bring the entire subject matter of the text up to date and to show the latest developments in the field of farm machinery.

PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON SOIL MECHANICS AND FOUNDATION ENGINEERING, June 22 to 26, 1936. Cambridge, Mass.: Harvard Univ., 1936, vol. 3, pp. VIII + 268 + [1] + 18, figs. [380]. Papers of significance to agricultural soil dynamics were included on Pressure Distribution, by F. Kogler (pp. 66-70); Discussion on the Distribution of Stress Around a Pile, by R. D. Mindlin (p. 71); A Graphical Method for Determining the Distribution of Stress in the Underground Due to Foundation Loads, by D. M. Burmister (pp. 71-73); A Method for Determining the Shearing Resistance of Fill Materials, Earth Embankments, etc., in Place by Means of a New Shear Apparatus, by D. M. Burmister (pp. 114-116); Discussion on Gilboy's Presentation of Jurgenson's Method of Foundation Analysis, by T. A. Middlebrooks (p. 118); Notes on the Stability of Slopes, by D. W. Taylor (pp. 118-122); Two Examples Concerning Underground Sliding Caused by Construction of Embankments and Static Investigations of the Effectiveness of Measures Provided to Assure Their Stability, by E. von Gottstein (pp. 122-128); Discussion on the Lateral Resistance of Piles, Paper No. H-1, by P. Raes and A. E. Cummings (pp. 138-140); Pressure Distributions on Retaining Walls, by R. D. Mindlin (pp. 155, 156); Direct Measurement of the Permeability of the Ground, by J. P. Daxelhofer (pp. 164, 165); and Comparative Studies of the Effectiveness of Different Methods for Compacting Cohesionless Soils, by W. Loos (pp. 174-179).

BIBLIOGRAPHY ON LAND DRAINAGE, compiled by *D. W. Graf.* U. S. Dept. Agr., Bur. Agr. Engin., 1936, pp. [1] + 245. This mimeographed bibliography contains an author index in addition to the list of publications. *(Continued on page 572)*

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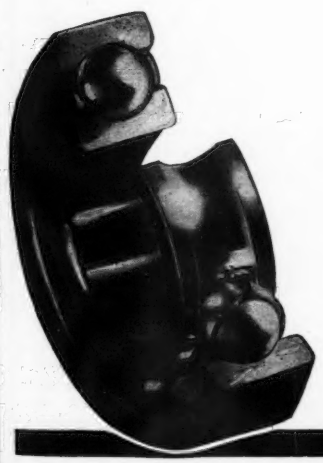

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BALL AND ROLLER BEARINGS

3988

Agricultural Engineering Digest

(Continued from page 570)

SOME FACTS UNDERLYING THE ATTRACTION OF MOSQUITOES TO SOURCES OF RADIANT ENERGY, *T. J. Headlee.* Jour. Econ. Ent., 30 (1937), No. 2, pp. 309-312. The results obtained by the New Jersey Experiment Stations in an investigation of the relationship existing between certain sources of radiant energy known to be attractive to mosquitoes and the number of mosquitoes caught under the same set of environmental conditions are reported.

Four of the New Jersey mosquito traps were set up, the sources of radiant energy employed being as follows: Trap 1, a 25-w white-frosted bulb, giving a white light, under the hood; trap 2, a tube filled with neon gas, giving a red light; trap 3, a tube filled with mercury vapor and so stained as to give a green-yellow light; trap 4, a tube filled with mercury argon vapor and unstained, giving a blue light. The vapor-filled tubes when subjected to high voltage blazed with light running through red, green-yellow, and blue. The tabulated results show that the "attraction power of the red light as measured in number of mosquitoes caught per microwatt is 6.1 times the number that would have been taken per microwatt in white light in trap 2, that the number of mosquitoes taken per microwatt in green-yellow is 12.3 times as many as would have been taken per microwatt with white light in trap 3, and that the number of mosquitoes taken per microwatt in blue light is 21.5 times as great as would have been taken per microwatt in white light in trap 4."

Earlier work has convinced the author that the 25-w white-frosted bulb does not produce an intensity even approaching that point on the curve of reaction where attraction turns to repellency.

HANDBOOK OF EROSION CONTROL ENGINEERING ON THE NATIONAL FORESTS, *E. W. Kramer, A. L. Anderson, and M. B. Arthur.* U. S. Dept. Agr., Forest Serv., 1936, pp. VI+90, figs. 72. The purpose of this handbook is to serve as a guide in carrying on erosion control work in the national forests. It emphasizes the control measures which apply to comparatively undeveloped or forested types of land rather than those for agricultural or cultivated areas. The greater part of the handbook deals with the design and construction of engineering structures which have proved practicable for erosion control work, and with the considerations which affect the choice and use of these structures. It contains chapters on the erosion problem on national forests, erosion control measures, hydraulics of erosion control, gully structures, estimated cost of restoring a gully, soil saving and debris dams, and miscellaneous structures.

MEANS FOR THE DETERMINATION OF THE MODE OF ACTION OF DRAINAGE SYSTEMS, CANALS, AND TILE DRAINS [trans. title], *E. Diserens* 3 Internatl. Cong. Soil Sci., Oxford, Eng., 1935, Trans., vol. 3, pp. 45-69, figs. 7. The author points out various ways in which drainage works, both canals and tile, influence the circulation of water in the soil, the aeration, the temperature, the permeability, condensation and evaporation, and the capacity of the soil to absorb fertilizers. Of these effects, that exerted upon the movement of water in the soil is emphasized as of outstanding importance to the proper operation of drainage systems. The general term "permeability" is held to cover two distinct characteristics or constants of the soil, both readily subjected to accurate measurement, namely, rapidity of filtration and permeability proper. It is further pointed out that, except in the case of sands which have no structure, there are differences between laboratory and field data representing the constants named, so that these constants, to be used as a guide in connection with drainage, and irrigation works, should be determined in the field.

Other physical characteristics of soils are also discussed with respect to their relation to drainage systems and the effects of such works upon soils.

One of the points emphasized is that soil drainage systems are to be recommended not merely in regions of high or moderate humidity but also in areas where soils of little permeability are used under irrigation.

PREVENTING SOIL BLOWING ON THE SOUTHERN GREAT PLAINS, *E. F. Chilcott.* U. S. Dept. Agr., Farmers' Bul. 1771 (1937), pp. [2]+29, figs. 21. Tillage practices and implements used for the prevention of soil blowing are described together with cropping practices.

TREATMENT OF MILK WASTES—AMERICAN AND EUROPEAN PRACTICE, *A. M. Buswell.* Milk Plant Mo., 26 (1937), No. 1, pp. 28-30, fig. 1. This contribution from the University of Illinois presents a technical discussion of the treatment of milk wastes.

INVESTIGATIONS ON THE MECHANICAL APPLICATION OF FERTILIZERS FOR COTTON IN NORTH CAROLINA, WITH SOME RESULTS FOR OTHER CROPS OBTAINED IN OTHER STATES, *E. R. Collins.* North Carolina Sta. Agron. Inform. Circ. 104 (1937), pp. [1]+17, figs. 4. Results obtained in cooperative experiments with the U. S. Department of Agriculture, 1931-36, showed that the maximum benefit from normal and higher rates of fertilizer applications can be assured by side placement from 2 to 3 in to the side and from 2 to 3 in below the level of the seed. Placement to one side of the seed gave practically as good results as application to both sides. With a normal or heavy fertilizer application, high in nitrogen or potassium, to avoid injury the seed should not be placed too close to the fertilizer. Preliminary results indicated that where the fertilizer is applied in bands from 5 to 6 in apart, 3 in below the seed, and seed planted with a walking planter, good stands and yields are obtained.

Results obtained elsewhere by the U. S. Department of Agriculture and other agencies in fertilizer placement tests with other crops are also summarized.

SYNTHETIC MANURE-HEATED HOTBEDS, *E. F. Burk.* Amer. Soc. Hort. Sci. Proc., 32 (1935), pp. 603, 604, fig. 1. At the Oklahoma Experiment Station, hotbeds heated by a mixture of 7 lb of calcium cyanamide with 100 lb of prairie hay, straw, cotton burs, Bermuda grass, and weeds compared favorably with horse manure in efficiency. Treated cotton burs gave a higher temperature than horse manure and prairie grass an equal temperature. An advantage for calcium cyanamide was that the nitrogen formed NH_3, which did not leach readily, and the calcium formed calcium carbonate, which favored alkalinity.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE INDIANA STATION. Indiana Sta. Rpt. 1936, pp. 8-16, figs. 6. The progress results are briefly reported of investigations on electric fences, electric heaters for fruit washers, use of electric energy in brooding chicks, power consumption of portable and stationary spray plants, electric dairy water heaters, soil heating with electric energy, storage of sweetpotatoes, precooling fresh fruits in refrigerator cars, cornstalk covering equipment, mechanical corn production, mechanical corn picker loss, Canada thistle-control equipment, rubber tires versus steel wheels for tractors, combined harvester-threshers, combining oats, air-cooled apple storages, low-pressure pneumatic tires for manure spreaders, hay and grain drying, and soil conservation.

THE DEPENDENCE OF CARBON DIOXIDE ASSIMILATION IN A HIGHER PLANT ON WAVE LENGTH OF RADIATION, *W. H. Hoover* Smithsn. Misc. Collect., 95 (1937), No. 21, pp. 13, pls. 3, figs. 4. "The rate of photosynthesis on the basis of equal incident energy was determined as a function of the wave length of light for a wheat plant. The entire visible spectrum is effective in producing photosynthesis. The wave length limits, although not accurately determined, appear to be between 7,200 au and 7,500 au on the red end, and less than 3,650 au on the blue end of the spectrum. A principal maximum occurs at 6,550 au in the red, and a secondary one at 4,4002au in the blue. Increased reflection and transmission of radiation in the green region by plant leaves diminish the effectiveness of incident green rays to promote photosynthesis."

RECENT DEVELOPMENTS IN DWELLING CONSTRUCTION. Fed. Housing Admin. Tech. Bul. 1, rev. (1937), pp. 17. This report represents the approach which is being made to better construction at lowered costs and an evaluation of the work which has been done, together with tentative conclusions as to its probable effect on the dwelling market. Brief descriptions of the different materials and methods of construction which are being tried out, together with lists of the individuals and concerns who have been engaged in such work, are also included. This includes some methods developed and used in Europe.

REFRIGERATION FOR THE FARM HOUSEHOLD AND FARM PRODUCE. Indiana Sta. Rpt. 1936, p. 48. This progress report summarizes the results of a survey of 144 rural homes in the state to obtain information on the adequacy of present refrigeration for the food supply of the farm household and farm produce.

EROSION STUDIES BY THE WASHINGTON STATION, *G. M. Horner and P. C. McGrew.* Washington Sta. Bul. 342 (1936), pp. 69-71. Progress results are briefly reported of investigations on effect of plant cover on run-off and erosion, movement and balance of soil moisture, tillage and cultivation practices for erosion control, cropping practices in relation to erosion control, terracing, gully control, tree planting for erosion control, and wind erosion.

(Continued on page 574)

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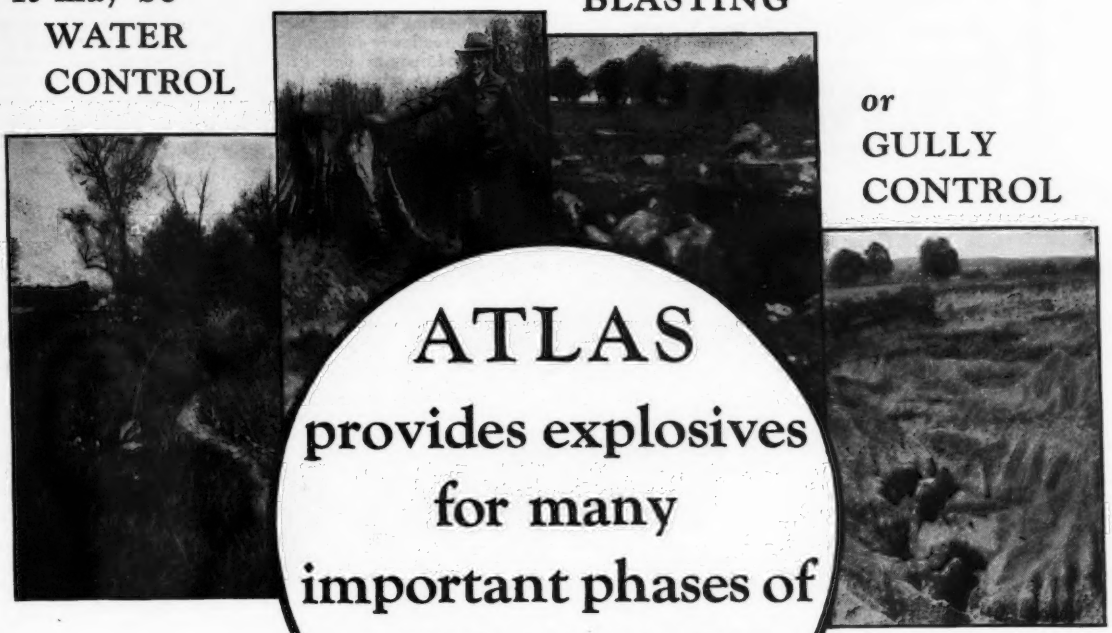

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Agricultural Engineering Digest

(Continued from page 572)

COMPARISON OF RUNOFF AND EROSION IN PRAIRIE, PASTURE, AND CULTIVATED LAND, *J. E. Weaver* and *W. C. Noll*. Nebr. Univ., Conserv. and Survey Div., Conserv. Dept. Bul. 11 (1935), pp. 37, figs. 11. The results of run-off and erosion measurements from entire watersheds and from run-off plats are presented and discussed.

Enclosed plats 3 ft wide and 33.3 ft long were used in these studies. Natural rainfall was supplemented by artificial watering. Runoff on a 10-deg slope from 26.88 in of rainfall during 15 mo was 2.5 per cent from prairie, 9.1 from overgrazed pasture, and 15.1 per cent from a pasture entirely bared by close grazing. The soil was Carrington silt loam. No measurable amount of soil eroded from the prairie, and only a small amount from the pasture, but 5.08 tons per acre were lost from the bare area.

Runoff from 4 in of water applied to pasture and prairie, respectively, in July 1934, at the rate of 2 in per hour (including 1 in applied in 15 min) at intervals 2 weeks apart, resulted in 3.1 and 9.8 per cent runoff. In April of the next year 2.5 in were applied at the same rate to prairie, pasture, and bare area. Run-off losses were 0, 29.3, and 50.4 per cent, respectively, and losses by erosion at the rate of 0, 165 lb, and 3.42 tons of soil per acre.

In October, after another summer of close grazing and root deterioration, 3 in of water were applied in 1.5 hr to each area. Runoff from prairie, pasture, and bare area was 11.3, 50.5, and 71.6 per cent, respectively, and soil losses from erosion at the rate of 0, 355 lb, and 4.67 tons per acre. Water penetration was nearly four times as great in prairie as in pasture.

Runoff on a 5-deg slope from 12.9 in of rainfall during a period of 11 mo was 1 per cent from the prairie, 12.1 from wheatfield, and 17.8 per cent from fallow land. The soil was Carrington silt loam. No measurable erosion occurred in prairie, 0.52 ton of soil per acre eroded from the wheatfield, and 2.6 tons from the fallow land.

Five in of water were applied to prairie and wheat stubble and 4 in to fallow land during a period of 2 days. Runoff was 3.1, 27.6, and 23.2 per cent, respectively, and soil erosion was at the rate of 0, 1,29, and 1.75 tons per acre in the same sequence.

Runoff from prairie and young alfalfa on Carrington silt loam with a 5-deg slope during a period of about 7 mo was 3.8 and 19.2 per cent, respectively, from a total rainfall of 10.6 in.

Four in of water applied to each plat in spring when the alfalfa was 5 in tall resulted in 5.9 per cent runoff in prairie and 40.8 per cent in alfalfa. No erosion occurred in the grassland, but 0.72 ton per acre in the field.

Runoff resulting from the application of 3 in of water in 1.5 hr on May 10 on a 7-deg slope on Lancaster sandy loam was nil from burned prairie, but 20 per cent from broken prairie cropped to corn for a period of 6 yr. Topsoil lost by erosion was at the rate of 12.2 tons per acre.

A soil covered with its natural mantle of climax vegetation represents conditions most favorable to maximum absorption of rainfall and maximum erosion control.

ON THE DETERMINATION OF THE DRAINAGE RATE [trans. title], *V. Setinski*. 3. Internatl. Cong. Soil Sci., Oxford, Eng., 1935, Trans., vol. 3, pp. 163, 164, fig. 1. The author here presents, in abbreviated form, the development of an education for the rate of drainage of a given volume of a soil.

RESULTS OF AGRONOMIC-HYDROTECHNICAL DRAINAGE EXPERIMENTS ON CLAY SOILS [trans. title], *H. Flodkvist*. 3. Internatl. Cong. Soil Sci., Oxford, Eng., 1935, Trans., vol. 3, pp. 164-168. The author briefly discusses the movement of water in drained soils and presents the bases of a theory, applicable within certain limiting conditions, with regard to transverse drainage.

PHOTOPERIODIC RESPONSE OF CERTAIN LONG AND SHORT DAY PLANTS TO FILTERED RADIATION APPLIED AS A SUPPLEMENT TO DAYLIGHT, *R. B. Withrow and J. P. Biebel* (Plant Physiol., 11 (1936), No. 4, pp. 807-819, figs. 10). This contribution from the Indiana Experiment Station reports the results of a study of the effects of three bands of radiation, used to prolong normal winter days to 18 hr, on the photoperiodic responses of three long-day plants (*Callistephus chinensis, Helianthus cucumerifolius,* and *Scabiosa atropurpurea*), and three short-day plants (*Salvia splendens, Cosmos bipinnatus,* and *Tithonia speciosa*). The wave bands included red (650–1,400 mmu), green (455–550 mmu), and blue (380–510 mmu). The results and conclusions are given in detail.

The long-day plants bloomed early under days prolonged with red and white radiation. Aster, seeded in winter, produced higher dry weights (tops and total) under the red. The blue induced earlier flowering in aster and sunflower, but not in *Scabiosa*. Aster and sunflower failed to flower as quickly under green and control conditions as under the red. *Scabiosa* had not bloomed under the blue, green, or control conditions by late spring. The three short-day plants remained in the vegetative condition when the days were lengthened by red and white radiation, but flowered in short days and days lengthened by blue and green light. Red light caused a decrease in synthesized dry matter.

Aster, seeded in the fall (12½-hr day), failed to respond reproductively when the days were lengthened as designated, and the plants in all the plats bloomed about the same time. When germinated in a shorter day (9½ hr), the response was as indicated above. *Salvia* from clonal cuttings, with all plants in flower when placed under days lengthened by wave bands as indicated, reverted to the vegetative state under red and white light but remained in the flowering condition under the other treatments. Corn, producing carpellate flowers in the tassel under short days, was prevented from producing such inflorescences by the red and white light used to prolong the day, but not by the blue or green.

It is concluded that, under the conditions imposed, red radiation is most effective in producing the photoperiodic response, both in short- and long-day plants; that some especially sensitive plants (e. g., aster) respond to the blue light; and that green radiation has little effect when used to prolong the day.

SOME ASPECTS OF SOIL EROSION CONTROL IN THE UNITED STATES, *H. Kohnke* and *J. S. Cutler*. 3. Internatl. Cong. Soil Sci., Oxford, Eng., 1935, Trans., vol. 2, pp. 177-180. The authors, both of the USDA Soil Conservation Service, summarize the present erosion situation in the United States in the statement that "it may be said that the safe use of land in different areas depends upon the productive capacity and the slope of the land. In general, the more gentle slopes can be economically protected from excessive erosion by purely agronomic methods, such as fertilization, planned crop rotations, strip cropping, and contour tillage, or by the use of terraces. The steeper lands can be economically utilized as meadow or pasture, while the excessively steep slopes can best be devoted to forest, climatic conditions permitting, or to pasture. Farm management studies have shown that the adoption of erosion control methods will result in no immediate loss of return and over a period of years actually increase the income of the farmer."

THE ACTION OF RADIATION OF SPECIFIC WAVE-LENGTHS IN RELATION TO THE GERMINATION OF LIGHT-SENSITIVE LETTUCE SEED, *L. H. Flint*. Compt. Rend. Assoc. Internatl. Essais Semences (Proc. Internatl. Seed Testing Assoc.), 8 (1936), No. 1, pp. 1-4, fig. 1. Continuing this series of studies, the present work made use of specific wavelengths employing a large spectrum, a single-filament incandescent light source, a condenser lens, concentration of light on an adjustable slit, an achromatic lens, a prism, and a silvered mirror. The detailed results given make it apparent that some components of white light promote germination while others inhibit it. The net effect of white light on germination is thus indicated as associated with the dominance of either the promoting or the inhibiting influence. Hence, in those seeds whose germination is hindered by white light a relatively greater absorption of the radiation inhibiting germination is suggested. In light-sensitive lettuce seed the net effect of white light is to promote germination.

The wavelengths inhibiting and promoting germination are correlated, respectively, with those inducing bending of plants toward the light and those promoting carbon fixation. It is thus concluded that the study of seed germination may have an intimate and important bearing not only on the immediate problems relating to seeds, but also on a wide range of problems covering the activities of plants in general.

STEM AND LEAF ANATOMY AS INFLUENCED BY SUPPLEMENTAL LIGHT, *F. Ramaley*. Colo. Univ. Studies, 23 (1936), No. 3, pp. 245-250, figs. 24. Of the 25 plant species from various families given full winter daylight exposure in the greenhouse, with additional illumination increasing the day length 4 hr or more (using electric lamps furnishing 30 footcandles at the level of the plants), 15 showed no appreciable anatomical differences between plants given long and short-day exposures. In some species, however, the experimental plants were slenderer than controls exposed only to winter daylight, the vascular tissue was greatly reduced, the vessels tended to be smaller, and the phloem elements were smaller and fewer in number. Starch was usually absnt from the experimental plants. The leaves were less modified than the stems, although a general tendency existed for leaves of the treated plants to be thinner, with a looser spongy tissue. Roots of experimental plants were nearly always reduced, especially as to the vascular tissue.

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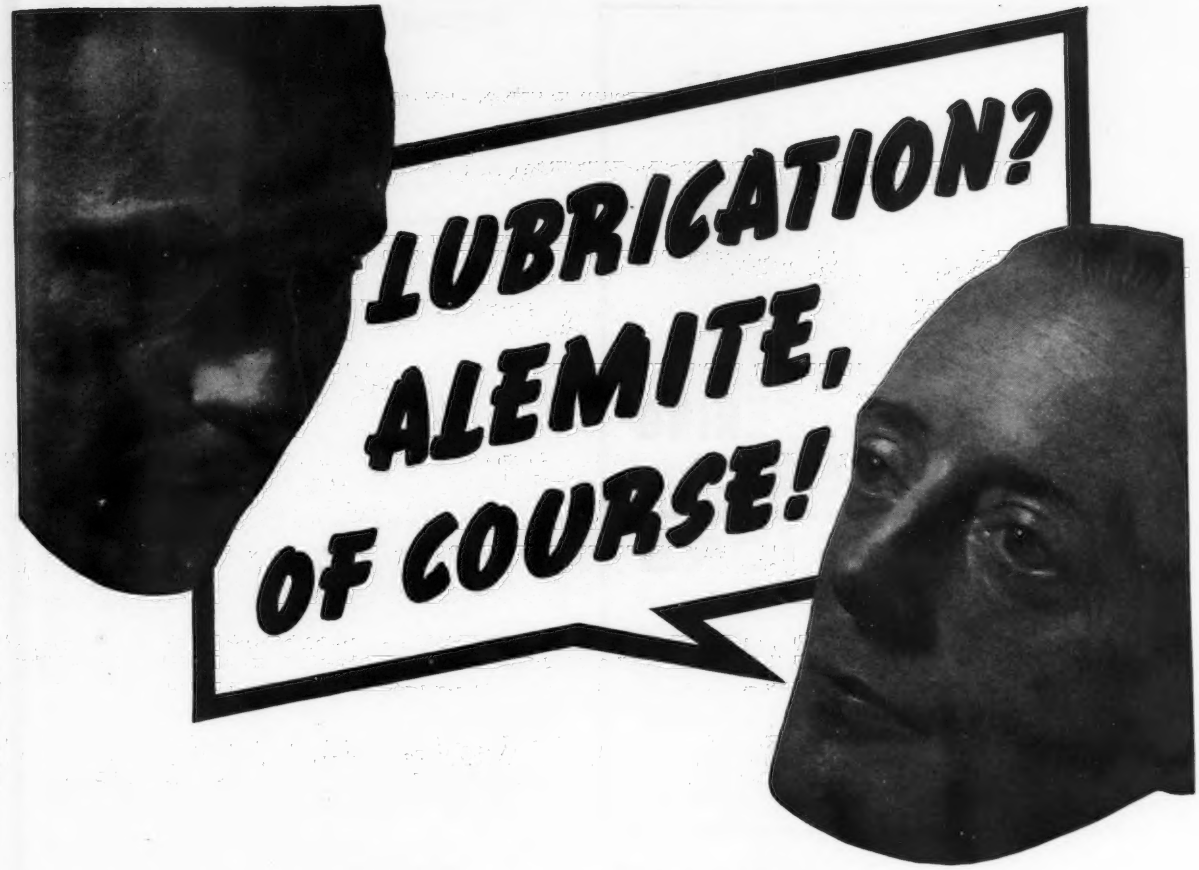

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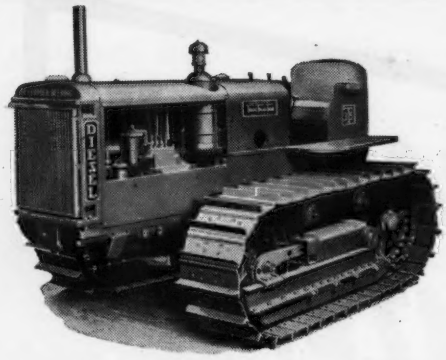

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Agricultural Engineering Digest

(Continued from page 574)

KEROSENE COOK STOVES, *M. M. Monroe* and *P. S. Greene.* Maine Sta. Bul. 384 (1936), pp. 406, 407. This preliminary report on a study of the economical management of kerosene cook stoves in Maine farm households to secure palatability of the product deals with the objectionable features for top-of-stove cooking of present burner designs.

Literature Received

A combined "Text Book, Sales Manual, and Catalog" in a loose-leaf binder has recently been published by the National Lightning Protection Company of St. Louis, Missouri. Numerous photographic examples of action of and destruction done by lightning are shown, together with information on right and wrong methods of providing protection for buildings, chimneys, radio aerials, trees, and special structures. The book is not for sale, but is loaned to dealers and other interested persons in consideration of a $2.00 fee and an agreement as to its care, use, and return on demand by the company.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

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DESIGNERS and layout men familiar with grain, hay, and corn harvesting machinery wanted by a leading manufacturer of farm equipment. Must be high-grade men. PO-115

AGRICULTURAL ENGINEERS familiar with farm building construction, particularly in the field of brick and hollow tile, and with farm drainage, particularly of sour soils and for erosion control, tion, particularly in the field of brick and hollow tile, and with farm drainage, particularly of sour soils and for erosion control, wanted by a midwest brick and tile manufacturer of 40 years experience. Opportunity for advancement for the right men. High-class men between ages of 25 and 35 years; married men preferred. PO-119

DESIGNER, who is an experienced graduate engineer, is wanted by a farm equipment manufacturer for designing agricultural implements. PO-120

POSITIONS WANTED

AGRICULTURAL ENGINEER with a farm background desires employment in the field of soil erosion control, irrigation, or farm machinery. Educational or demonstrational work preferred. Holds a degree in agricultural engineering from a middle western university. Has one year's experience in highway engineering and three year's experience as a CCC camp engineer for the Soil Conservation Service. Has had considerable experience in contacting and working with farmers. Married. Age 28. PW-282

AGRICULTURAL ENGINEER, graduate of the A. & M. College of Texas, desires employment in the field of soil conservation. Has farm background, has been employed by a county agent, and employed since June 1936 by the International Harvester Company of Houston, Texas. Age 26. Single. PW-283

AGRICULTURAL ENGINEER with B.S. degree in electrical engineering, M.S. degree in agricultural engineering from the State College of Washington, with one year's experience in the USDA agricultural extension service and 2½ years' experience in rural electrification under J. C. Scott, agricultural engineer of the Puget Sound Power and Light Co., desires position in agricultural engineering in the rural electrification field or research and teaching position with a college or experiment station. Now employed, age 27. Working toward engineering degree in June 1938. PW-284

AGRICULTURAL ENGINEER, 1936 graduate, with one and one-half year's experience in rural electrification, wants employment preferably in rural electric extension work, but will consider openings in other agricultural engineering work. Age 26. Particular experience in southwestern area. PW-285

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AGRICULTURAL ENGINEERING

DECEMBER 1937

Systems for Delivering Fuel Oil to Orchard Heaters *F. A. Brooks*

A Simple and Inexpensive Drawbar Dynamometer *A. T. Hendrix*

Organization for Promotion of Better Farm Buildings *K. J. T. Ekblaw*

The Spontaneous Heating and Ignition of Hay *H. E. Roethe*

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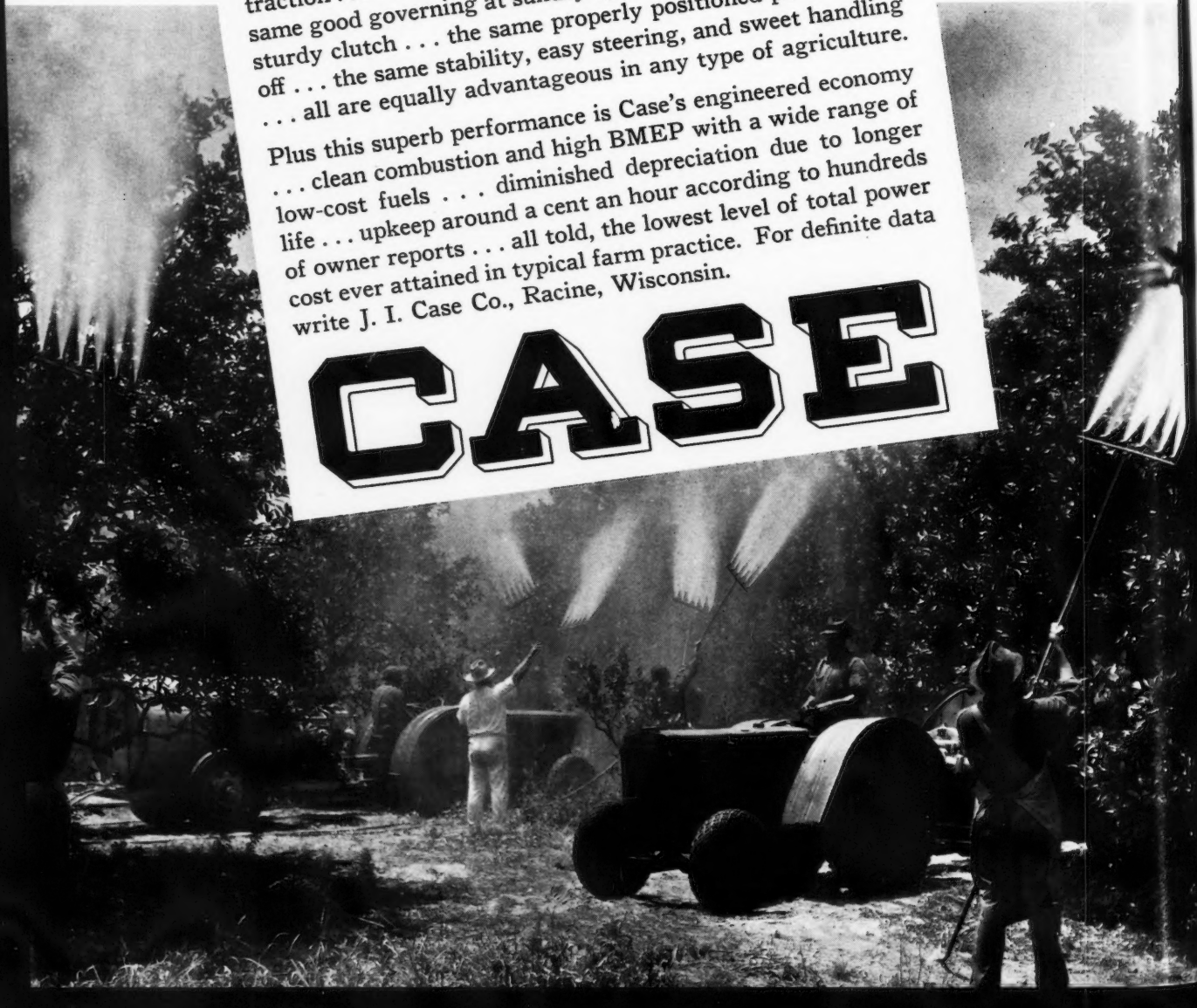

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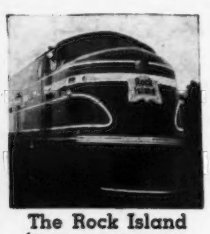

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